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MATERIALS MANUAL NO. 5

STEEL STRUCTURES PAINTING COUNCIL

SURFACE PREPARATION SPECIFICATIONS FOR STRUCTURAL STEEL

MEASUREMENT OF DRY PAINT THICKNESS WITH MAGNETIC GAGES

materials bureau technical services division

JULY 1986

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STEEL STRUCTURES PAINTING COUNCIL
4400 Fifth Avenue
Pittsburgh, PA 15213

APPROVED NOVEMBER 1, 1982 AND MARCH 1, 1985

BR1a (7/86) M.A.P. 7.42-4-5

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July 1986

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1220 WASHINGTON AVENUE, ALBANY, NY 12232

M.A.P. CODE 7.42-4-5

November 1, 1982
and
March 1, 1985

CHAPTER 2

SURFACE PREPARATION SPECIFICATIONS

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1985

November 1, 1982
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March 1, 1985

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Published by
STEEL STRUCTURES PAINTING COUNCIL
4400 Fifth Avenue
Pittsburgh, PA 15213

Third Edition, First Printing, November 1, 1982
Fourth Edition - March 1, 1985

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATIONS
Surface Preparation Commentary

1. Introduction

This Surface Preparation Commentary is intended to be an aid for selecting the proper surface preparation specifications for a given job and for determining when the desired surface preparation is accomplished. The Commentary is not part of the actual specifications, but is included in order to provide a better understanding of the SSPC surface preparation specifications. In addition, surface preparation specifications other than those published by SSPC are referenced.

The SSPC specifications, summarized in Table 1, were thoroughly reviewed between 1975 and 1982 and represent a broad consensus of users, suppliers, and public interest groups. Certain rewordings were effected for clarification of the specifications, but no changes in the basic requirements were made or intended. Many details previously presented in the specifications themselves are now found in this Commentary.

2. Importance of Surface Preparation

The life of a coating depends as much on the degree of surface preparation as on the subsequent coating system. Surface preparation, therefore, should receive thorough consideration. The primary functions of surface preparation are:

- To clean the surface of material that will induce premature failure of the coating system.
- To provide a surface that can be easily wetted for good coating adhesion.

It must be borne in mind that all coating systems will fail eventually. However, most premature coating failure can be attributed to inadequate surface preparation or lack of coating adhesion.

Typical contaminants that should be removed during surface preparation are moisture, oil, grease, chloride salts, sulfate salts, rust, corrosion products, and dirt. Mill scale is erratic in its effect upon the performance of coatings. Tightly adhered or intact mill scale does not have to be removed for mild atmospheric exposure. If, however, the steel surface is to be coated with primers with low wetting properties or exposed to severe environments such as chemical exposures and immersion in fresh or salt water, then removal of mill scale by blast cleaning to a minimum SSPC-SP 10, "Near-White Blast Cleaning," is necessary.

3. Initial Surface Conditions

The amount of work, time, and money required to achieve any particular degree of thoroughness of surface preparation will depend upon the initial condition of the surface to be cleaned. It is much more difficult to remove contaminants from rusty steel than from intact mill scale. Therefore, it is necessary to consider the amount of mill scale, rust, old paint, contamination, and pitting on the surface to be protected. Although there are almost an infinite number of initial conditions, they can be broadly divided into three categories as follows:

- New construction — steel not previously painted;
- Maintenance — previously painted steel;
- Surface imperfections — common to both new construction and maintenance.

3.1 NEW CONSTRUCTION: The first four surface conditions (designated A through D) are based upon the rustgrade classifications of SSPC-Vis 1, "Pictorial Surface Preparation Standards for Painting Steel Surfaces." Normally, a more thorough surface preparation should be used with rustgrades C or D compared with rustgrades A or B.

A Steel surface covered completely with adherent mill scale with little, if any rust (SSPC-Vis 1 — Rustgrade A).

B Steel surface which has begun to rust, and from which the mill scale has begun to flake (SSPC-Vis 1 — Rustgrade B).

C Steel surface from which most of the mill scale has rusted away or from which it can be scraped, but with little pitting visible (SSPC-Vis 1 — Rustgrade C).

D Steel surface where the mill scale has rusted away and where pitting is visible (SSPC-Vis 1 — Rustgrade D).

3.2 MAINTENANCE: Four grades of previously painted steel have also been established and represent the range of initial surface conditions encountered in maintenance repainting. The maximum amounts of rust in grades E, F, G, and H represent a geometric progression with each percentage ten times that of the preceding grade (0.1%, 1%,

TABLE 1
SUMMARY OF SURFACE PREPARATION SPECIFICATIONS

SSPC Specification	SSPC-Vis 1 Photograph	Description
SP 1, Solvent Cleaning		Removal of oil, grease, dirt, soil, salts, and contaminants by cleaning with solvent, vapor, alkali, emulsion, or steam.
SP 2, Hand Tool Cleaning	B, C, D St 2	Removal of loose rust, loose mill scale, and loose paint to degree specified, by hand chipping, scraping, sanding, and wire brushing.
SP 3, Power Tool Cleaning	B, C, D St 3	Removal of loose rust, loose mill scale, and loose paint to degree specified, by power tool chipping, descaling, sanding, wire brushing, and grinding.
SP 5, White Metal Blast Cleaning	A, B, C, D Sa 3	Removal of all visible rust, mill scale, paint, and foreign matter by blast cleaning by wheel or nozzle (dry or wet) using sand, grit, or shot. (For very corrosive atmospheres where high cost of cleaning is warranted.)
SP 6, Commercial Blast Cleaning	C, D Sa 2	Blast cleaning until at least two-thirds of the surface area is free of all visible residues. (For rather severe conditions of exposure.)
SP 7, Brush-Off Blast Cleaning	B, C, D Sa 1	Blast cleaning of all except tightly adhering residues of mill scale, rust, and coatings, exposing numerous evenly distributed flecks of underlying metal.
SP 8, Pickling		Complete removal of rust and mill scale by acid pickling, duplex pickling, or electrolytic pickling.
SP 10, Near-White Blast Cleaning	B, C, D Sa 2-1/2	Blast cleaning nearly to White Metal cleanliness, until at least 95% of the surface area is free of all visible residues. (For high humidity, chemical atmosphere, marine, or other corrosive environments.)
Vis 1, Pictorial Surface Preparation Standards for Painting Steel Surfaces		Photographic standards used as specification; optional supplement to SSPC Surface Preparation Specifications 2, 3, 5, 6, 7, and 10.
Vis 2, Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces		A geometric numerical scale for evaluating degree of rusting of painted steel. Illustrated by color photographs and black and white dot diagrams.

10%, 100%). These grades are consistent with those established in the photographic standard SSPC-Vis 2/ASTM-D 610, "Standard Method of Evaluating Degree of Rusting on Painted Surfaces."

E Paint almost intact; some primer may show; rust covers less than one-tenth of one percent of the surface (SSPC-Vis 2 — Rustgrades 8 to 10).

F Finish coat somewhat weathered; primer may show; slight staining or blistering; after stains are wiped off, less than one percent of area shows rust, blistering, loose mill scale, or loose paint film (SSPC-Vis 2 — Rustgrades 6 to 8).

G Paint thoroughly weathered, blistered, or stained; up to ten percent of surface is covered with rust, rust blisters, hard scale or loose paint film; very little pitting visible (SSPC-Vis 2 — Rustgrades 4 to 6).

H Large portion of surface is covered with rust, pits, rust nodules, and non-adherent paint. Pitting is visible (SSPC-Vis 2 — Rustgrades 0 to 4).

In approximating estimates of rust percentages, photographs and schematic diagrams of the type shown in SSPC-Vis 2 can serve as practical aids. Figure 1 of the Guide to SSPC-Vis 2 shows a series of 1.5 inch squares with black dots representing various area percentages. These diagrams are not intended to reproduce the appearance of actual rust patterns but merely to serve as a guide for judging the percentage of surface covered by rust (after removal of stains) or rust blisters. The SSPC Painting System Commentary will also help in estimating surface preparation requirements.

Comments on surface preparation for maintenance repainting are given in SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems." This guide includes a description of accepted practices for retaining old, sound paint, removing unsound paint, feathering, and spot cleaning.

4. Surface Imperfections

Surface imperfections can cause premature failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features which are difficult to properly cover and protect include crevices, weld porosity, laminations, etc. They are discussed below. The high costs of the methods to remedy the surface imperfections requires weighing the benefits of edge rounding, weld spatter removal, etc., versus a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the actual surface preparation operation (e.g., blast cleaning). Alternately, other surface defects — such as steel laminations, weld porosities, or deep corrosion pits — may not be evident until the surface preparation operation has been done. Therefore, the timing of such surface repair work may occur before, during, or after preliminary surface preparation operations have begun.

4.1 WELD SPATTER: Weld spatter should be removed prior to blast cleaning. Most weld spatter, except that which is very tightly adherent, can be readily removed using a chipping hammer, spud bar, or scraper. Tightly adhering weld spatter may require removal by grinding.

4.2 POROSITY: Areas of unacceptable porosity as defined in the American Welding Society standard AWS D1.1 should be filled with acceptable filler material or closed over with a needle gun or peening hammer prior to painting. Acceptable weld profiles, arc strikes, and weld cleaning are also addressed in Section 3 of "Structural Welding Code" AWS D1.1.

4.3 SHARP EDGES: Sharp edges, such as those normally occurring on rolled structural members or plates, as well as those resulting from flame cutting, welding, grinding, etc., and especially shearing, may be removed by any suitable method (e.g., grinding, mechanical sanding, filing). Care should be taken to ensure that during the removing operations, new sharp edges are not created.

4.4 PITS: Deep corrosion pits, gouges, clamp marks, or other surface discontinuities may require grinding prior to painting. The surface will require filling.

4.5 LAMINATIONS, SLIVERS: Rolling discontinuities (laps) may have sharp protruding edges and deep penetrating crevices and such defects should be eliminated prior to painting. Various methods can be used to eliminate minor slivers (e.g., scraping and grinding). All sharp fins, projections, or edges should be removed.

4.6 CREVICES: Areas of poor design for corrosion protection, such as tack or spot welded connections, back-to-back angles, crevices, etc., may require special attention. Where possible, such deficiencies should be corrected by structural or design modification. Where this is not possible, particular consideration should be devoted to minimize the effect of such deficiencies.

5. Abrasive Selection

The selection of the size and type of abrasive which will most effectively and economically produce the desired surface finish is not, unfortunately, an exact science, because of the many variables involved. These variables include at least the following:

- The nature of the steel being cleaned, i.e., the hardness and the degree of rusting which may have developed prior to blast cleaning.
- The basic purpose for blast cleaning, which may include either new construction or maintenance and repair programs.
- The type of surface finish desired, i.e., degree of cleanliness and height of profile required to meet the specification or requirement of the paint to be applied. See SSPC report on "Surface Profile for Anti-Corrosion Paints."
- The type of blast cleaning systems which may be employed, e.g., centrifugal wheel or airblast recirculating abrasive systems for shop or on-site cleaning, or on-site, open nozzle airblasting with non-recoverable abrasives.

In general, select the smallest size abrasive that will produce the desired cleaning results. Usually, this will give the fastest, most economical cleaning operation.

General information concerning the chemical and physical properties of cast steel shot and grit, and the physical properties of various non-metallic abrasives along with information on their usage, are presented in the following sections.

5.1 CAST STEEL ABRASIVES: Steel shot consists of nearly spherical particles of steel obtained by granulating a molten stream of metal with water, air, or other methods. Steel shot will generally conform to the Society of Automotive Engineers SAE J827 (Recommended Practice) in terms of hardness, chemical composition, size, and microstructure.

Cast steel grit consists of angular particles produced by crushing steel shot (SAE J827). Steel grit is available in a wide range of hardnesses, from 30 to 66 Rockwell C, produced by varying the tempering time cycles to which the grit is subjected. Generally, the three hardnesses most commonly produced are in the ranges of 40-50 Rockwell C, 55-60 Rockwell C, and 60-66 Rockwell C. The first two hardness ranges are used for structural steel, and the latter is used primarily for selective application where deep, consistent, sharp etched finishes are required, or where moderate etches on extremely hard surfaces are needed.

Steel shot will produce a peened surface texture whereas steel grit produces more of an etched surface texture. The etch becomes more pronounced with increasing abrasive hardness.

Typical applications of various steel abrasives, referring to rustgrade classifications described in Section 3.1 are:

- Shot: Commonly used for Rustgrades A and B.
- Grit (40-50 RC): Most effective on Rustgrades C and D, but also commonly used for Rustgrades A and B.
- Shot/Grit (Shot 40-50 RC/Grit 55-60 RC Mixture): This is not common practice; however, it is acceptable for all Rustgrades, particularly for Rustgrades C and D. NOTE: Such a mixture is difficult to maintain in the desired proportions in a workmix (operating mix) of shot/grit since the grit, being harder and more friable than the shot, will break down at a faster rate than the shot. However, the desired proportions of shot/grit can be maintained, in the operating mix, *provided* new abrasive added to the machine is of the proper proportions. Generally speaking, the amount of grit in the newly added mix must be greater than the amount of grit desired in the operating mix. Maintaining this type of operating mix therefore demands careful attention and close control of abrasive additions by the operator.

Tables 2, 3, 4A, and 4B summarize the properties of metallic abrasives, types and sizes most commonly used for various cleaning operations, and the SAE shot and grit size specifications.

5.2 NON-METALLIC ABRASIVES will vary in shape, size, hardness, and density. The abrasives should be clean and free from contaminants, and graded properly for the specific product. Tables 5, 6 and 7 provide information on abrasive selection.

TABLE 2
STEEL SHOT AND GRIT SPECIFICATIONS[4]

Property	Shot	Grit
SIZE:		
New abrasive as manufactured	All material is screened to meet or exceed SAE #J444 and SFSA #20-66 Specifications[1]	
CHEMISTRY:		
Carbon	0.85 to 1.20 %	
Manganese	0.60 to 1.00 %	
Silicon	0.50 to 1.00 %	
Sulfur	< 0.05 %	
Phosphorous	< 0.05 %	
MICROSTRUCTURE:	Uniformly tempered martensite, with fine, well distributed carbides, if any. Carbide networks, transformation products, decarburized surfaces, inclusions, and quench cracks are undesirables.	
HARDNESS:		
Commonly used structural steel[2]	40 to 50 RC	40 to 50 RC[3] 40 to 60 RC

[1] SAE (Society of Automotive Engineers, Inc.)
400 Commonwealth Drive
Warrendale, PA 15096

SAFA (Steel Founders' Society of America)
20611 Center Ridge Road
Rocky River, Ohio 44116

[2] Both cast steel shot and grit of hardnesses in the range of from 30 to 66 Rockwell C may be purchased. However, the abrasives of less than 40 RC and greater than 60 RC are generally used for applications other than surface preparation of structural steel.

[3] Abrasive manufacturers identify steel grit by designations which include two or more prefix letters, followed by the number size. Prefix letters are different for each of the abrasive suppliers for any given hardness range.

[4] It is *extremely important* that contractual documents which specify abrasives to be used clearly *designate* the *abrasive by size and by hardness.*

TABLE 3
TYPES OF STEEL ABRASIVES MOST COMMONLY USED FOR VARIOUS STRUCTURAL STEEL BLAST CLEANING OPERATIONS

	Abrasive Type		Size Range[1]	Hardness (RC)	
	Shot	Grit		40 to 50	55 to 60
New Steel	X		S170 to S390	X	
Fabricated New Steel	X		S170 to S390	X	
		X	G50 to G25	X	X
Heat-Treated Steel		X	G50 to G25		X
Heavy Steel Plate	X		S230 to S390	X	
Corroded Steel		X	G50 to G25		X
Weld Scale	X		S170 to S280	X	
Brush Blast	X		S170 to S280	X	
Repair Work		X	G50 to G40	X	
Maintenance		X	G80 to G18	X	X

[1] *Size range* refers to *working mix (operating mix)* for recirculating abrasive blast systems. For additional information see Volume 1, Chapter 2 of the "Steel Structures Painting Manual"

TABLE 4A
CAST SHOT SPECIFICATIONS FOR SHOT PEENING OR BLAST CLEANING

NBS Screen No.	Standard[a] (mm)	Screen Size (in)	Screen Opening Sizes and Screen Numbers with Maximum and Minimum Cumulative Percentages Allowed on Corresponding Screens SAE Shot Number													
			S1320	S1110	S930	S780	S660	S550	S460	S390	S330	S280	S230	S170	S110	S70
4	4.75	0.187	All Pass	—	—	—	—	—	—	—	—	—	—	—	—	—
5	4.00	0.157	—	All Pass	—	—	—	—	—	—	—	—	—	—	—	—
6	3.35	0.132	90% min	—	All Pass	—	—	—	—	—	—	—	—	—	—	—
7	2.80	0.111	97% min	90% min	—	All Pass	—	—	—	—	—	—	—	—	—	—
8	2.36	0.0937	—	97% min	90% min	—	All Pass	—	—	—	—	—	—	—	—	—
10	2.00	0.0787	—	—	97% min	85% min	—	All Pass	All Pass	—	—	—	—	—	—	—
12	1.70	0.0661	—	—	—	97% min	85% min	—	5% max	All Pass	—	—	—	—	—	—
14	1.40	0.0555	—	—	—	—	97% min	85% min	—	5% max	All Pass	—	—	—	—	—
16	1.18	0.0469	—	—	—	—	—	97% min	85% min	—	5% max	All Pass	—	—	—	—
18	1.00	0.0394	—	—	—	—	—	—	96% min	85% min	—	5% max	All Pass	—	—	—
20	0.850	0.0331	—	—	—	—	—	—	—	96% min	85% min	—	10% max	All Pass	—	—
25	0.710	0.0278	—	—	—	—	—	—	—	—	96% min	85% min	—	10% max	—	—
30	0.600	0.0234	—	—	—	—	—	—	—	—	—	96% min	85% min	—	All Pass	—
35	0.500	0.0197	—	—	—	—	—	—	—	—	—	—	97% min	—	10% max	—
40	0.425	0.0165	—	—	—	—	—	—	—	—	—	—	—	85% min	—	All Pass
45	0.355	0.0139	—	—	—	—	—	—	—	—	—	—	—	97% min	—	10% max
50	0.300	0.0117	—	—	—	—	—	—	—	—	—	—	—	—	80% min	—
80	0.180	0.007	—	—	—	—	—	—	—	—	—	—	—	—	90% min	80% min
120	0.125	0.0049	—	—	—	—	—	—	—	—	—	—	—	—	—	90% min
200	0.075	0.0029	—	—	—	—	—	—	—	—	—	—	—	—	—	—

[a]Corresponds to ISO Recommendations.

TABLE 4B
CAST GRIT SPECIFICATIONS FOR BLAST CLEANING

NBS Screen No.	Standard[a] (mm)	Screen Size (in)	Screen Opening Sizes and Screen Numbers with Minimum Cumulative Percentages Allowed on Corresponding Screens SAE Grit Number											
			G10	G12	G14	G16	G18	G25	G40	G50	G80	G120	G200	G325
4	4.75	0.187	—	—	—	—	—	—	—	—	—	—	—	—
5	4.00	0.157	—	—	—	—	—	—	—	—	—	—	—	—
6	3.35	0.132	—	—	—	—	—	—	—	—	—	—	—	—
7	2.80	0.111	All Pass	—	—	—	—	—	—	—	—	—	—	—
8	2.36	0.0937	—	All Pass	—	—	—	—	—	—	—	—	—	—
10	2.00	0.0787	80%	—	All Pass	—	—	—	—	—	—	—	—	—
12	1.70	0.0661	90%	80%	—	All Pass	—	—	—	—	—	—	—	—
14	1.40	0.0555	—	90%	80%	—	All Pass	—	—	—	—	—	—	—
16	1.18	0.0469	—	—	90%	75%	—	All Pass	—	—	—	—	—	—
18	1.00	0.0394	—	—	—	85%	75%	—	All Pass	—	—	—	—	—
20	0.850	0.0331	—	—	—	—	—	—	—	—	—	—	—	—
25	0.710	0.0278	—	—	—	—	85%	70%	—	All Pass	—	—	—	—
30	0.600	0.0234	—	—	—	—	—	—	—	—	—	—	—	—
35	0.500	0.0197	—	—	—	—	—	—	—	—	—	—	—	—
40	0.425	0.0165	—	—	—	—	—	80%	70%	—	All Pass	—	—	—
45	0.355	0.0139	—	—	—	—	—	—	—	—	—	—	—	—
50	0.300	0.0117	—	—	—	—	—	—	80%	65%	—	All Pass	—	—
80	0.180	0.007	—	—	—	—	—	—	—	75%	65%	—	All Pass	—
120	0.125	0.0049	—	—	—	—	—	—	—	—	75%	60%	—	All Pass
200	0.075	0.0029	—	—	—	—	—	—	—	—	—	70%	55%	—
325	0.045	0.0017	—	—	—	—	—	—	—	—	—	—	65%	20%

[a]Corresponds to ISO Recommendation.

CAST SHOT AND GRIT SIZE SPECIFICATIONS FOR PEENING AND CLEANING—SAE J444a
SAE Recommended Practice*

Report of Production Division approved January 1946 and last revised by Mechanical Prestressing of Metals Division November 1976.

[This SAE Recommended Practice pertains to blast cleaning and shot peening and provides for standard cast shot and grit size numbers. It supersedes the previous SAE Recommended Practice, Shot for Peening. For shot, this number corresponds with the aperture size of the nominal screen. For grit, this number corresponds with the number of the nominal screen with the prefix G added. These screens are in accordance with the National Bureau of Standards series as given in ASTM-E 11, Specification for Sieves for Testing Purposes.

The accompanying shot and grit classifications and size designations were formulated by representatives of shot and grit suppliers, equipment manufacturers, and automotive users who constituted the Shot Peening Division of the Iron and Steel Technical Committee.]

Shot should be round and solid. When used for peening or cleaning, round, solid shot withstands breakage better than irregularly shaped or porous particles.

As used in the actual peening process, it is highly desirable that the shot be reasonably spherical and reasonably solid. It must be within the desired size limits.

Since it may be more economical for the user to mechanically *season* the shot, the degree of control of shape and quality of shot may be established by agreement between user and shot supplier.

Testing Procedure

1. (a) A rotating and tapping type of testing machine shall be used.
   (b) The shaking speed shall be 275-295 rpm.
   (c) The taps per minute shall be 145-160, when tapping machines are used.
2. The size of the sample shot shall be 100 g, to be obtained from a representative quantity.
3. Screening sieves shall be in accordance with the National Bureau of Standards series as given in ASTM-E 11. They shall be of the 8 in. (203 mm) diameter series, of either standard 1 in. (25 mm) or 2 in. (51 mm) height.
4. The time of test shall be 5 min ± 5 s for shot size up to and including U.S. Standard Screen size 35; and 10 min ± 5 s for finer screen sizes.
5. Any alternate method agreed upon between the supplier and user which gives equivalent results will be acceptable.

Grit for Cleaning — See Table 4B.

Cross References:

SAE J827 — Cast Steel Shot: for information on Composition and Shapes.

SAE J445 — Metallic Shot and Grit Mechanical Testing: for information on Shot Quality Determination.

*Reprinted with the permission of the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA. 15096.

TABLE 5
PHYSICAL DATA ON NON-METALLIC ABRASIVES

	Hardness (Mohs Scale)	Shape	Sp. Gr.	Bulk Density (lb/cu ft)	Color	Free Silica Wt. %	Degree of Dusting	Reuse
Naturally Occurring Abrasives								
SANDS:								
Silica	5	Rounded	2 to 3	100	White	90+	High	Poor
Mineral	5 to 7	Rounded	3 to 4	125	Variable	< 5	Medium	Good
FLINT	6.7 to 7	Angular	2 to 3	80	Lt. Grey	90+	Medium	Good
GARNET	7 to 8	Angular	4	145	Pink	Nil	Medium	Good
ZIRCON	7.5	Cubic	4.5	185	White	Nil	Low	Good
NOVACULITE	4	Angular	2.5	100	White	90+	Low	Good
By-Product Abrasives								
SLAGS:								
Boiler	7	Angular	2.8	85	Black	Nil	High	Poor
Copper	8	Angular	3.3	110	Black	Nil	Low	Good
Nickel	8	Angular	2.7	85	Green	Nil	High	Poor
WALNUT SHELLS	3	Cubic	1.3	45	Brown	Nil	Low	Poor
PEACH SHELLS	3	Cubic	1.3	45	Brown	Nil	Low	Poor
CORN COBS	4.5	Angular	1.3	30	Tan	Nil	Low	Good
Manufactured Abrasives								
SILICON CARBIDE	9	Angular	3.2	105	Black	Nil	Low	Good
ALUMINUM OXIDE	8	Blocky	4.0	120	Brown	Nil	Low	Good
GLASS BEADS	5.5	Spherical	2.5	100	Clear	67	Low	Good

TABLE 6
TYPE OF MINERAL ABRASIVE RECOMMENDED FOR VARIOUS BLAST CLEANING OPERATIONS

	Bulk Density (lbs/cu ft)		Size Range[1]			Hardness	
	>100	<100	Coarse	Medium	Fine	Hard	Soft
New Steel	X		X			X	
Fabricated New Steel	X			X		X	
Heat-Treated Steel	X		X			X	
Heavy Steel Plate	X		X			X	
Corroded Steel	X			X		X	
Weld Scale	X			X		X	
Brush Blast		X			X		X
Repair Work	X		X			X	
Maintenance							

[1] Coarse: + #20 NBS Screen
Medium: – #25 + #45 NBS Screen
Fine: – #50 NBS Screen

TABLE 7
THRESHOLD LIMIT VALUES (TLV) FOR MINERAL DUSTS[3]

Substance	Threshold Limit Value
SILICA (Crystalline):	
Quartz	300 / (% quartz + 10) mppcf[1,2]
Cristobalite	Use one-half value from quartz formula
Diatomaceous Earth	1.5 mg/cu m, Respirable dust
SILICA (Amorphous):	5 mg/cu m, Total dust (all sample sizes) 2 mg/cu m, Respirable dust (<5 microns)
SILICATES (<1% Quartz):	
Asbestos, all forms	5 fibers/cc > 5 microns in length
Graphite (Natural)	15 mppcf[1]
Mica	20 mppcf[1]
Portland Cement	30 mppcf[1]
Soapstone	20 mppcf[1]
Talc (Non-asbestiform)	20 mppcf[1]
Talc (Fibrous)	Use asbestos limit
Tremolite	See Asbestos

[1] mppcf: millions of particles per cubic foot of air, based on impinger samples counted by light-field techniques.

[2] The percentage of quartz in the formula is the amount determined from airborne samples, except in those instances in which other methods have been shown to be applicable.

[3] Reprinted from the American Conference of Governmental Industrial Hygienists booklet entitled "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment," 1981 edition. These TLVs are revised annually.

6. Surface Profile

Surface profile is a measurement of the roughness of the surface which results from abrasive blast cleaning. The height of the profile produced on the surface is measured from the bottoms of the lowest valleys to the tops of the highest peaks.

The profile depth (or height) is dependent upon the size, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, and amount of recycling of working mixtures of grit and shot.

Therefore the maximum permissible size of the abrasive particles will depend upon the paint system thickness. The allowable maximum height of the profile is usually dependent upon the thickness of paint to be applied.

SSPC studies have shown that metallic abrasives larger than those which will pass through a #16 NBS screen may produce a profile which is too deep to be adequately covered with a single coat of primer. Accordingly, it is recommended that the use of larger abrasives be avoided whenever possible. However, when heavy mill scale or rust are present, abrasives of a larger size may be needed. In these cases two coats of shop primer should be applied instead of the usual one coat.

Table 8 gives the range of maximum and average maximum profile heights to be expected under normal good operating conditions (wheel and nozzle). If excessively high air pressure or wheel speed is used, the profile may be significantly higher.

Profile Comparators are available from the SSPC to aid in estimating the average maximum profile of surfaces blasted with sand, steel grit, and steel shot.

A report, "Surface Profile for Anti-Corrosion Paints," is available from the SSPC describing methods of measuring profile, and relating profile to blast cleaning conditions and to coating performance.

TABLE 8
TYPICAL MAXIMUM PROFILES PRODUCED BY SOME COMMERCIAL ABRASIVE MEDIA

Abrasive	Maximum Particle Size NBS Screen No.	Typical Profile Height (mils) Maximum	Av. Maximum
STEEL ABRASIVES[1]:			
Shot S230	−#18 +#20	2.9 ±0.2	2.2 ±0.3
Shot S280	−#16 +#18	3.5 ±0.3	2.5 ±0.4
Shot S330	−#14 +#16	3.8 ±0.4	2.8 ±0.5
Shot S390	−#12 +#14	4.6 ±0.5	3.5 ±0.7
Grit G50	−#25 +#30	2.2 ±0.3	1.6 ±0.3
Grit G40	−#18 +#20	3.4 ±0.4	2.4 ±0.5
Grit G25	−#16 +#18	4.6 ±0.5	3.1 ±0.7
Grit G14	−#10 +#12	6.5 ±0.8	5.1 ±0.9
MINERAL ABRASIVES:			
Flint Shot	Medium-Fine	3.5 ±0.4	2.7 ±0.4
Silica Sand	Medium	4.0 ±0.5	2.9 ±0.4
Boiler Slag	Medium	4.6 ±0.5	3.1 ±0.5
Boiler Slag	Coarse	6.0 ±0.7	3.7 ±0.7
Heavy Mineral Sand	Medium-Fine	3.4 ±0.4	2.6 ±0.4

[1] Profile heights shown for steel abrasives were produced with conditioned abrasives of stabilized operating mixes in recirculating abrasive blast cleaning machines. Profile heights produced by new abrasives having screen analyses shown in Tables 4A and 4B will be appreciably higher

Cast Steel Shot: Hardness 40 to 50 Rockwell C

Cast Steel Grit: Hardness 55 to 60 Rockwell C

7. Visual Standards

Note that visual standards, when used in conjunction with SSPC specifications, give only an approximation of the final surface condition. It is cautioned, therefore, that any visual standards should be considered a supplement to, and not a substitute for, surface preparation specifications. The use of the visual standards in conjunction with SSPC specifications is required only when they are specified in the procurement document covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement document.

7.1 SSPC-Vis 1, "Pictorial Surface Preparation Standards for Painting Steel Surfaces," are available as a separate publication of color photographs. They were originally prepared by the Swedish Standards Institute Corrosion Committee, supplemented by the SSPC, and approved by the American Society for Testing and Materials (ASTM), Swedish Standards Institution (SIS), Danish Standards Association, Standards Association of Australia, Jugoslovenski Zavod Za Standardizaciju, European Committee of Paint and Printing Ink Manufacturers' Association, American National Standards Institute (ANSI), National Association of Corrosion Engineers (NACE), and the Steel Structures Painting Council (SSPC). They may be obtained from the SSPC, ASTM, or SIS.

The color photographs in the pictorial standard represent four rustgrades of hot-rolled structural steel surfaces, described as A, B, C, and D in Section 3.1. Approximate reproductions of some photographs are included as part of the Guide to SSPC-Vis 1. The SSPC-Vis 1 standard book also includes two degrees of thoroughness of hand cleaning and three or four degrees of blast cleaning for each of these four rustgrades. The SSPC-Vis 1 photographs depicting the grades of surface preparation prior to painting are cross-referenced to the SSPC surface preparation specifications in the Guide to SSPC-Vis 1.

7.2 NACE STANDARDS TM-01-70 AND TM-01-75: The National Association of Corrosion Engineers has developed visual standards for evaluating the degree of cleanliness of steel blast cleaned with sand, steel grit, or steel shot. Steel test panels have been individually cleaned to each of the four degrees of blast cleaning and sealed with plastic to prevent rusting. Both NACE and SSPC have been careful to see that NACE Grades 1 (White), 2 (Near-White), 3 (Commercial), and 4 (Brush-Off), and their definitions correspond closely to those of SSPC-SP 5, 10, 6, and 7 respectively.

7.3 OTHER PHOTOGRAPHIC STANDARDS: The American Rust Standard System, Inc., has issued photographs illustrating 24 degrees of rustiness in uncleaned, hot-rolled steel.

The Production Technical Society (Japan) has printed color illustrations of wash primed and zinc-rich primed steel before and after weathering and re-cleaning. The photographs of the Shipbuilding Association of Japan illustrate the appearance of painted, unpainted, welded,

and flame-cut steel before and after various degrees of damage or weathering.

The Society of Naval Architects and Marine Engineers (SNAME) has issued a booklet of photographs illustrating typical appearances of painted and unpainted steel before and after being blast cleaned to grades "in between" SSPC-SP 5, 6, 7, and 10.

The State of Maryland pictorial standards for shot blasting contain two photographs representing the surface conditions of SSPC-SP 6 (Commercial) and SSPC-SP 10 (Near-White) blast cleaning. (Steel rusted beyond SSPC-Vis 1, Rustgrade C is deemed unacceptable.)

7.4 PROJECT PREPARED STANDARDS: Prepared steel will often appear differently from the photographic standards due to variations in initial surface conditions, abrasives being used, and so forth. Because of difficulties in comparisons, it is sometimes recommended that the contractor provide blast cleaned samples representative of the steel to be blasted which, by mutual agreement of the owner and the contractor, are representative of the required surface cleanliness and appearance. Suggested dimension of the reference steel panels are 6″ x 6″ x 3/16″ minimum (approximately 15 cm x 15 cm x 0.5 cm). The blast cleaned panels should be completely protected from corrosion and contamination, and maintained as visual reference standards for the duration of the project.

8. Rust Back

Rust back occurs when freshly exposed bare steel is exposed to conditions of high humidity, moisture, or a corrosive atmosphere. The time interval between blast cleaning and rust back will vary greatly (from minutes to weeks) from one environment to another. Because of this factor, timeliness of inspection is of great importance. Inspection must be coordinated with the fabricators' schedule of operation in such a way as to avoid delay. Acceptance of the prepared surface must be made prior to application of the prime coat, because the degree of surface preparation cannot be readily verified after painting. To avoid potential deterioration of the surface, it must be assumed that surface preparation is accepted unless inspected and rejected prior to scheduled application of prime coat.

Under normal mild atmospheric conditions it is best to coat a blast cleaned surface within 24 hours after blast cleaning. Under no circumstances should the steel be permitted to rust back before painting, regardless of the time elapsed.

Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is therefore recommended that dry blast cleaning should not be conducted when the steel surface is less than 5 F° (3 C°) above the dew point.

Excessive weathering or exposure of steel to chemical fumes such as chlorides and sulfates prior to blast cleaning should be avoided since pitting of the steel may increase cleaning costs and makes removal of contaminants difficult. After blast cleaning, even slight residues of chlorides, sulfates, or other electrolytes on the steel surface may be harmful, and for some coatings, may cause premature coating failure.

9. Inhibitors

Steel that is wet blast cleaned will rust rapidly as a result of the water. It is essential that inhibitors be added to the water or applied to the surface immediately after blast cleaning to temporarily prevent rust formation. The coating should then be applied before any rusting is visible on the surface.

A suitable inhibitive treatment for blast cleaned surfaces is water containing 0.32% of sodium nitrite and 1.28% by weight of secondary ammonium phosphate (dibasic); alternatives are water containing about 0.2% by weight of chromic acid or sodium chromate or sodium dichromate or potassium dichromate. NOTE: If solutions containing either chromates or dichromates are used, precautions should be taken to protect personnel from hazards resulting from breathing spray or contacting the solution.

10. Film Thickness

It is essential that ample coating be applied after blast cleaning to adequately cover and protect the peaks of the surface profile. Thus, the depth of the surface profile should be considered in determining the amount of coating to be applied. For higher profiles a larger coating thickness should be specified. To assure that coating thicknesses are properly measured from the peaks of the profile, refer to SSPC-PA 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

11. Summary of SSPC Surface Preparation Specifications

Although these specifications are primarily intended for heavy metal or plate, most are also suitable for light weight or thin section metal. Obviously, caution must be exercised when using methods such as blast cleaning on metal of thin section since damage by warping or from excessive peening of the surface may occur. Occasions will arise where these specifications will not result in the type of cleaning desired. In such cases, the surface preparation specifications may be modified by the user to obtain the result desired. Regardless of which methods are used, adjacent equipment, pre-finished items, or surfaces that could be damaged from the method of surface preparation must be protected.

Occasionally in maintenance painting the previous paint is incompatible with the new paint. Under these circumstances all paint, regardless of condition, will have to be removed. A minimum of SSPC-SP 6, "Commercial Blast Cleaning" is usually necessary.

Volume 1 of the Steel Structures Painting Manual devotes several chapters to mechanical surface prepara-

tion, and it also discusses special surface preparation requirements for shops, maintenance, railroads, highways, tanks, vessels, refineries, and various types of plants. This volume should be consulted when choosing a specification.

The "Commentary on Paint Specifications" (Chapter 4 of Volume 2 of the Steel Structures Painting Manual) shows the minimum surface preparation required for each of the SSPC specification paints. Similarly, the "Commentary on Painting Systems" (Chapter 3 of Volume 2 of the Steel Structures Painting Manual) shows the recommended minimum surface preparation for each paint system and for the various individual alternative primers within each system, in ten common types of exposure. A brief summary is shown in Table 9.

11.1 SSPC-SP 1, "SOLVENT CLEANING": This solvent cleaning specification includes simple solvent wiping, immersion in solvent, solvent spray, vapor degreasing, steam cleaning, emulsion cleaning, chemical paint stripping, and alkaline cleaners.

Solvent cleaning is used primarily to remove oil, grease, dirt, soil, drawing compounds, and other similar organic compounds. Solvent cleaning may also be used to remove old paint by the use of paint removers or alkaline paint strippers. Inorganic compounds such as chlorides, sulfates, weld flux, rust, and mill scale are not removed by cleaning with organic solvents.

Many solvents are hazardous. Care must be taken when using solvents for solvent cleaning. Special safety precautions must be followed with regard to ventilation, smoking, static electricity, respirators, eye protection, or skin contact.

Alkaline cleaning compounds cover a very wide range in composition and method of use. These are discussed in detail in Volume 1 of the Steel Structures Painting Manual along with suitable solvents. It is important that residues of alkaline compounds do not remain on the surface after cleaning. The clean surface may be tested with litmus paper or universal indicating paper to see that it is neutral or at least no more alkaline than the rinse water that is used.

11.1.1 Petroleum and Coal Tar Solvents, and Turpentine: These types of solvents clean the metal by dissolving and diluting the oil and greases which contaminate the surface. Some solvents, especially coal tar solvents (aromatics), will also dissolve the vehicle of paints so they can be removed. It is important that the last wash or rinse be made with clean solvent in every case or a film of oil or grease will be left on the surface when the solvent of the last washing evaporates; this film may interfere with the bond of the paint to the metal.

Petroleum base mineral spirits (aliphatics), with a minimum flash point of 100° F (38° C), or "Stoddard Solvent" as per ASTM Specification D 484 should be used as the general purpose solvent for cleaning under normal conditions. In hot weather, or when the temperature is 80 to 95° F (25 to 35° C), high flash aliphatic mineral spirits with a minimum flash point of 120° F (50° C) should be used. In very hot weather, when the temperature is over 95° F (35° C), heavy mineral spirits with a flash point over 140° F (60° C) should be used. All solvents are potentially hazardous and they should be used under such conditions that their concentration in air being breathed by workmen is low enough for safety (see Table 10, Threshold Limit Values). When used in closed spaces where the safe concentration is exceeded, fresh air masks should be worn. The fresh air intake should be clear of carbon monoxide or other contaminants from engine exhausts or other sources. The concentration of solvent in air should not exceed the lower limit of flammability as fire or explosion may result. Gasoline and V.M. & P. Naphtha are too dangerous for use under ordinary conditions.

Aromatic or coal tar solvents may be used where greater solvency is required, but they are more toxic and the solvents generally available have low flash points.

TABLE 9
MINIMUM SURFACE PREPARATION REQUIRED BY SSPC PAINTING SYSTEM SPECIFICATIONS

SSPC PAINTING SYSTEM SERIES	MINIMUM SURFACE PREPARATION[1]
Oil Base	Hand Tool Cleaning (SSPC-SP 2)
Alkyd	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Phenolic	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Vinyl	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Rust Preventive Compounds	Solvent Cleaning (SSPC-SP 1) or Nominal Cleaning
Asphalt Mastic	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Coal Tar Coatings	Commercial Blast Cleaning (SSPC-SP 6)
Coal Tar Epoxy	Commercial Blast Cleaning (SSPC-SP 6)
Zinc-Rich	Commercial Blast Cleaning (SSPC-SP 6)
Epoxy Polyamide	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Chlorinated Rubber	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Silicone Alkyd	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Urethane	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)
Latex	Commercial Blast Cleaning (SSPC-SP 6) or Pickling (SSPC-SP 8)

[1] Where commercial blast cleaning is the minimum recommended surface preparation, better degrees of blast cleaning may be substituted. These methods are more thorough, and the better cleaning they provide may be more economical or may be required for moderately corrosive conditions. Consult the Commentary on Painting Systems (Chapter 5 of Volume 2 of the Steel Structures Painting Manual) for additional details.

TABLE 10
THRESHOLD LIMIT VALUES (TLV) FOR SOLVENTS[4]

Substance	Adopted Values TWA-TLV[1] ppm	Adopted Values TWA-TLV[1] mg/cu m	Adopted Values STEL-TLV[2] ppm	Adopted Values STEL-TLV[2] mg/cu m
Acetone	750	1780	1000	2375
Benzene (Benzol) — Skin	10	30	25	75
Butylcellosolve — Skin	25	120	75	360
Carbon Tetrachloride — Skin	5	30	20	125
Cyclohexane	300	1050	375	1300
Epichlorohydrin — Skin	2	10	5	20
Ethyl Acetate	400	1400	——	——
Ethanol (Ethyl Alcohol)	1000	1900	——	——
Ethylene Dichloride (1,2-Dichloroethane)	10	40	15	60
Ethylenediamine	10	25	——	——
Furfuryl Alcohol — Skin	10	40	15	60
Methanol (Methyl Alcohol) — Skin	200	260	250	310
Methylene Chloride (Dichloromethane)	100	350	500	1740
Naphtha, Coal Tar[3]	——	——	——	——
Naphtha, Petroleum[3]	——	——	——	——
Perchloroethylene — Skin	50	335	200	1340
Isopropyl Alcohol — Skin	400	980	500	1225
Stoddard Solvent	100	525	200	1050
Toluene	100	375	150	560
Trichloroethylene	50	270	200	1080
Turpentine	100	560	150	840
Xylene (Xylol)	100	435	150	655

[1] TWA-TLB (Threshold Limit Value — Time Weighted Average): The time weighted average concentration for a normal 8-hour workday or a 40-hour work week.

[2] STEL-TLV (Threshold Limit Value — Short Term Exposure Limit): The maximum concentration to which workers can be exposed for a period up to 15 minutes.

[3] In general, the aromatic hydrocarbon content will determine what TLV applies.

[4] Reprinted from the American Conference of Governmental Industrial Hygienists booklet entitled "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment," 1984-85 edition. These TLVs are revised annually. Note that OSHA limits may be different (sometimes lower). Therefore, following ACGIH recommendations can sometimes be illegal.

Benzol (benzene) is the most toxic and should not be used, particularly in view of its low flash point and attendant fire and explosion hazard. Xylol, toluol, and high flash naphtha may be used when their concentration in air that is being breathed does not exceed the safe limit (see Table 10). If the concentration is greater, fresh air masks should be worn. Because of the low flash points of these solvents, fire and explosion hazards are inherent with their use and great caution should be taken to ensure safe working conditions.

Chlorinated hydrocarbons may be used. However, due to toxicity, chlorinated hydrocarbons are not recommended for general use except with special equipment and trained operators. Chlorinated hydrocarbons should never be used where they may affect stainless steel.

"Safety Solvents" are satisfactory for use provided that they meet the flash point requirements above and that they are used under such conditions that the concentration of chlorinated hydrocarbons in air does not constitute a health hazard (see Table 10).

11.1.2 Alkaline Cleaners: These cleaners saponify certain oils and greases; their surface active constituents wash away other types of contaminants, such as oil. They may be particularly effective in removing paint because the alkali saponifies the dried paint vehicle. Since the soaps formed are soluble in water, the contaminants are more easily removed by washing with water after saponification, and the adhesive nature of the old paint is reduced by chemical action on the paint.

The most commonly used alkaline cleaner is trisodium phosphate, but there are other alkalies which are used. Some of these are mixtures with wetting agents and detergents. They are available as proprietary products and should be used in accordance with directions of the manufacturer.

Because of the paint removal action of many alkaline cleaners, the actual cleaner to be used should be chosen after consideration of the extent to which the paint may be damaged.

If no manufactured alkaline cleaner is available, good results may be achieved by the use of two ounces trisodium phosphate per gallon of water, to which is also added one to two ounces of soap or other suitable detergent. This solution is best used hot; if used cold, it may be advisable to increase the concentration. This solution is suitable for spraying or scrubbing; if used in dip tanks, the concentration may be tripled. If not washed from the surface, this mixture will soften and eventually loosen most paints. Where complete paint removal is the primary object, caustic soda (sodium hydroxide) may be substituted for the tri-sodium phosphate.

A soap film left on the surface is just as damaging to the paint bond as is an oil or grease film; therefore the surface should be thoroughly washed (preferably with hot water under pressure) to remove this soap and other residue. Moreover, all alkali must be thoroughly removed from the surface or the new paint will be saponified and damaged by it. To test the effectiveness of the wash, universal pH test paper should be placed against the wet steel. The pH of the washed surface should be no greater than the pH of the wash water.

Following the rinsing, steel surfaces should be passivated with an acidic wash containing about 0.1% by weight of chromic acid, or sodium dichromate, or potassium dichromate, to overcome the harmful effect of traces of alkali on paint adhesion. This passivating treatment may be applied by brushing, spraying, or dipping, but should not be used when chromate-free phosphatizing operations are to follow.

Alkaline cleaners must be used with caution since bad burns may result from contact with some solutions. Particular care should be paid to protecting the eyes of workers; safety goggles or eye shields should be worn. Rubber gloves should be worn if the solutions will contact workers' hands. Chromic acid and the chromates may cause dermatitis and precautions should be taken to protect the skin and hands of workers. Where alkaline cleaning compounds, chromic acid, or chromates are sprayed, respirators should be worn.

11.1.3 Emulsion Cleaners: Emulsion cleaners usually contain oil soluble soaps or emulsifying agents along with kerosene or mineral spirits. They are usually supplied as a concentrate which may be thinned with kerosene or mineral spirits and sprayed on the surface to be cleaned. They are emulsified by the action of water under pressure and washed away along with oil, grease, and other contaminants. They may be diluted with water, emulsified, and used in that condition. In any event, the directions of the manufacturer should be followed.

A residue of emulsion is almost always left on the surface. This residue will leave a thin film of oil on the surface. If the paint to be applied cannot tolerate a slight amount of oil, the residue must be washed from the surface by steam, hot water, detergents, solvents, or alkaline cleaning compounds.

Alkaline emulsion cleaners, which combine the advantages of the alkaline cleaners and the emulsion cleaners, are available.

11.1.4 Steam Cleaning: Steam cleaning may actually utilize either steam, hot water under pressure, or both.

The steam and hot water, when used to clean the surface, are usually used with a detergent and sometimes also with an alkaline cleaner. The steam and hot water themselves tend to remove the oils, greases, and soaps by thinning them with heat, emulsifying them, and diluting them with water. When used to remove old paint, the steam cooks the vehicle of the old paint so that it loses its strength and its bonding to the metal. It can then be easily removed by further washing. When detergent is used, its higher affinity for the metal also causes the oil, grease, and paint to loosen, thereby increasing the rate of cleaning.

The new paint will not adhere to the metal if any of the oil, grease, soap, detergent, or alkali is left on the surface. A final washing with clean water is therefore always necessary.

11.1.5 Threshold Limit Values: For threshold limit values of common cleaning solvents see the American Conference of Governmental Industrial Hygienists booklet entitled "Threshold Limit Values (TLV) of Airborne Contaminants for 1978 for Chemical Substances and Physical Agents in the Workroom Environment" (see Table 10).

11.2 SSPC-SP 2, "HAND TOOL CLEANING": Hand tool cleaning is an acceptable method of surface preparation for normal atmospheric exposures, for interiors, and for maintenance painting when using paints with good wetting ability. Hand cleaning will not remove all residue or rust nor will it remove intact mill scale. For cleaning small, limited areas prior to maintenance priming, hand cleaning will usually suffice.

It is important to follow the good practices outlined in this hand cleaning specification in order to minimize un-

necessary failures or to avoid unnecessarily stringent specifications for the preparation of surfaces which will be exposed in mild environments. Care in hand cleaning is also especially important if the prime coat is to be applied by spray.

The hand cleaning specification requires that oil and grease, along with any salts, be removed prior to hand tool cleaning as specified in SSPC-SP 1, "Solvent Cleaning." On welded work, particular care should be taken to remove as much welding flux, slag, and fume deposit as is possible since these are notorious in promoting paint failure on welded joints. All loose matter should be removed from the surface prior to painting; blowing it off with clean, dry, oil-free compressed air; brushing; or vacuum cleaning are satisfactory methods.

11.2.1 Loose Rust: Determination of the degree of cleaning required to comply with this specification is often very difficult. The problem is in establishing whether a residue is "adherent" or "loose." The specification considers the residue adherent if it cannot be lifted with a dull putty knife, a somewhat subjective criterion.

One possible solution is to establish a standard of cleaning through use of a specified cleaning procedure in which the type of brush, force, speed, etc., are stipulated. The surface for the standard (or the control) should be a flat portion of the surface actually to be cleaned.

It is emphasized that this establishes a standard of cleanliness, *but not a production rate.* As long as the surface is cleaned as well as that in the standard cleaning, the actual production rate is not in question. The standard is of value in case of any difference of opinion as to whether or not the surface has been properly cleaned.

11.2.2 Visual Standards: If mutually agreed upon, SSPC-Vis 1 or other visual references may be used to supplement the cleaning criteria of this specification. For partially rusted mill scale, for completely rusted mill scale, or for completely rusted and pitted surfaces, the appearance of the surface after hand tool cleaning should correspond to pictorial standards B St 2, C St 2, or D St 2 of SSPC-Vis 1. Other cleaning specifications and visual standards are described in Sections 7 and 12 of this Commentary.

11.3 SSPC-SP 3, "POWER TOOL CLEANING": Power tool cleaning provides a better foundation for the priming paint than hand tool cleaning. If properly done in compliance with the specification, better paint performance should result.

The power tool cleaning specification requires that oil and grease, along with any salts, be removed prior to power tool cleaning as specified in SSPC-SP 1, "Solvent Cleaning." On welded work, particular care should be taken to remove as much welding flux, slag, and fume deposit as is possible since these are notorious in promoting paint failure on welded joints. All loose matter should be removed from the surface prior to painting. Blowing off with clean, dry, oil-free compressed air, brushing, or vacuum cleaning are satisfactory methods.

Care is necessary in the use of power tools to prevent excessive roughening of the surface as ridges and burrs contribute to paint failure because sharp edges are not protected by adequate thickness of paint. Excessive power wire brushing can also be detrimental to the performance of the paint; mill scale is easily burnished to a smooth, slick surface to which paint will not adhere.

11.3.1 Loose Rust: Determination of the degree of cleaning required to comply with this specification is often very difficult. The problem is in establishing whether a residue is "adherent" or "loose." The specification considers the residue adherent if it cannot be lifted with a dull putty knife, a somewhat subjective criteria.

One possible solution is to establish a standard of cleaning through use of a specified cleaning procedure in which the type of brush, force, speed, etc., are all stipulated. The surface for the standard (or the control) should be a flat portion of the surface actually to be cleaned. It is emphasized that this establishes a standard of cleanliness, *but not a production rate.* As long as the surface is cleaned as well as that in the standard cleaning, the actual production rate of cleaning is not in question. The standard is of value in case of any difference of opinion as to whether or not the surface has been properly cleaned.

11.3.2 Visual Standards: If mutually agreed upon, SSPC-Vis 1 or other visual references may be used in place to supplement the cleaning criteria of this specification. For partially rusted mill scale, for completely rusted mill scale, or for completely rusted and pitted surfaces, the appearance of the surface after power tool cleaning should correspond to pictorial standards B St 3, C St 3, or D St 3 of SSPC-Vis 1. These pictures represent steel given an extra-thorough hand cleaning but in appearance may be considered typical of average power tool cleaned surfaces. Other cleaning specifications and visual standards are described in Sections 7 and 12 of this Commentary.

11.4 SSPC-SP 4, "FLAME CLEANING OF NEW STEEL": This specification was discontinued in 1982.

11.5 SSPC-SP 5, "WHITE METAL BLAST CLEANING": White Metal Blast Cleaning is generally used for exposures in very corrosive atmospheres and for immersion service where the highest degree of cleaning is required and a high surface preparation cost is warranted.

Blast cleaning to white metal will result in high performance of the paint systems due to the complete removal of all rust, mill scale, and foreign matter or contaminants from the surface. In ordinary atmospheres and general use white metal is seldom warranted.

The use of this grade of blast cleaning without rust back is particularly difficult in the environments where it is most needed as a preparation for painting; for example, in humid chemical environments. White Metal Blast Cleaning should be conducted at a time when no contamination or rusting can occur, and when prompt painting is possible. A good rule is that no more surface should be prepared for painting than can be coated the same day.

When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned in accordance with this specification and the amount of spot cleaning required. In maintenance painting it is not ordinarily intended that sound, adherent old paint be removed unless it is excessively thick, inflexible, or incompatible with the specified paint system. SSPC-PA 1, "Shop, Field, and Maintenance Painting," and SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," cover additional maintenance painting procedures.

11.5.1 Visual Standards: If mutually agreed upon, SSPC-Vis 1 or other visual references may be used to supplement the cleaning criteria of this specification. For partially rusted mill scale, for completely rusted mill scale, or for completely rusted and pitted surfaces, the appearance of the surface after White Metal Blast Cleaning should correspond to pictorial standards A Sa 3, B Sa 3, C Sa 3, or D Sa 3 of SSPC-Vis 1. The color or hue of the cleaned surface may be affected by the nature of the steel, the abrasives, and by previous painting. Other cleaning specifications and visual standards are described in Sections 7 and 12 of this Commentary.

11.6 SSPC-SP 6, "COMMERCIAL BLAST CLEANING": Commercial Blast Cleaning should be employed for all general purposes where a high, but not perfect, degree of blast cleaning is required. It will remove all rust, mill scale, and other detrimental matter from the surface, but will permit a great deal of staining from rust or mill scale to remain. The surface will not necessarily be uniform in color, nor will all surfaces be uniformly clean. If the cleaning done according to this specification is likely to result in a surface unsatisfactory for severe service, then Near-White Blast Cleaning or White Metal Blast Cleaning should be specified. The advantage of Commercial Blast Cleaning lies in the lower cost for satisfactory surface preparation for the majority of cases where blast cleaning is believed to be necessary.

When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned in accordance with this specification and the amount of spot cleaning required. In maintenance painting it is not ordinarily intended that sound, adherent old paint be removed unless it is excessively thick, inflexible, or incompatible with the specified paint system. SSPC-PA 1, "Shop, Field, and Maintenance Painting," and SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," cover additional maintenance painting procedures.

11.6.1 Visual Standards: If mutually agreed upon, SSPC-Vis 1 or visual references may be used to supplement the cleaning criteria of this specification. For completely rusted mill scale, or for completely rusted and pitted surfaces, the appearance of the surface after Commercial Blast Cleaning should correspond to pictorial standard C Sa 2 or D Sa 2 of SSPC-Vis 1. NOTE: The current B Sa 2 photograph (1982) is not representative of Commercial Blast Cleaning. Also note that a photograph is not available for a commercial blast over an intact mill-scale-bearing surface, as this is considered impractical. The color or hue of the cleaned surface may be affected by the nature of the steel, the abrasives, and by previous painting. Other cleaning specifications and visual standards are described in Sections 7 and 12 of the Commentary.

11.6.2 As with all SSPC specifications, the referenced standard in effect on the date of invitation to bid shall govern unless otherwise specified.

11.7 SSPC-SP 7, "BRUSH-OFF BLAST CLEANING": Brush-Off Blast Cleaning should be employed when the environment is mild enough to permit tight mill scale, paint, and minor amounts of tight rust and other foreign matter to remain on the surface. The surface resulting from this method of surface preparation should be free of all loose mill scale and loose rust. The small amount of rust remaining should be an integral part of the surface. The remaining paint and mill scale should be tight and the surface sufficiently abraded to provide a good anchor for paint. The low cost of this method may result in economical protection in mild environments.

It is not intended that Brush-Off Blast Cleaning be used for very severe surroundings. Brush-Off Blast Cleaning is generally intended to supplant power tool cleaning where facilities are available for blast cleaning. With this method of surface preparation, as with any other, it is understood that the rate of cleaning will vary from one part of the structure to another depending upon the initial condition of the surface. Because of the high rate of cleaning, the cost is low relative to the higher grades of blast cleaning, and should be of the same order as hand cleaning. Considerable amounts of tight intact paint, tight rust, or small particles of tightly adhered mill scale will remain after brush-off blasting; therefore, the paints which are used should have a fair degree of wetting.

When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned in accordance with this specification and the amount of spot cleaning required. In maintenance painting it is not ordinarily intended that sound, adherent old paint be removed unless it is excessively thick, inflexible, or incompatible with the specified paint system. SSPC-PA 1, "Shop, Field, and Maintenance Painting," and SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," cover additional maintenance painting procedures.

11.7.1 Visual Standards: If mutually agreed upon, SSPC-Vis 1 or other visual references may be used to supplement the cleaning criteria of this specification. For partially rusted mill scale, for completely rusted mill scale, or for completely rusted and pitted surfaces, the appearance of the surface after Brush-Off Blast Cleaning should correspond to pictorial standards B Sa 1, C Sa 1, or D Sa 1 of

SSPC-Vis 1. Other cleaning specifications and visual standards are described in Sections 7 and 12 of this Commentary.

11.8 SSPC-SP 8, "PICKLING": Pickling is considered a desirable method of removing rust and mill scale from structural shapes, beams, and plates when the cost of such removal is felt to be justified. Properly accomplished, pickling produces a surface that will promote long paint life with most coatings.

Where production is sufficiently high to keep the equipment in use, pickling results in low cost shop preparation. It is impractical for field use although some experimental work has indicated the possibility of field pickling by use of poultices.

Facilities are extremely limited for pickling of large fabricated members or large structural beams. However, there are a number of facilities for large steel plates and structural members not exceedingly long. Small scale pickling facilities are widely available.

Hydrochloric acid dissolves scale faster than sulfuric acid, but hydrochloric acid is seldom heated because of the extreme difficulty associated with the fumes which evolve upon heating. Any acid which is used should be used with a suitable inhibitor. Considerable use is made of the duplex type of pickling where sulfuric acid is used to remove the rust and scale, and phosphoric acid is used for a final phosphate treatment. Special precautions including fresh water rinsing are necessary to remove residues of unreacted sulfuric or hydrochloric acid.

Design of fabricated steel may require special consideration to eliminate pockets or crevices which trap acid during pickling. This may be avoided by pickling in phosphoric acid. Pickled steel, like blast cleaned steel, should be painted as soon as possible after cleaning. A more detailed discussion of pickling is available in Volume 1 of the Steel Structures Painting Manual.

11.9 SSPC-SP 9, "WEATHERING FOLLOWED BY BLAST CLEANING": This specification was discontinued in 1971. Weathering prior to blast cleaning has been found to be a very harmful practice, especially in corrosive environments, since deleterious surface impurities are much more difficult to remove after weathering away of mill scale.

11.10 SSPC-SP 10, "NEAR-WHITE BLAST CLEANING": In many exposures involving a combination of high humidity, chemical atmosphere, marine, or other corrosive environment, the use of White Metal Blast Cleaning was found to be overly expensive due to the disproportionately large amount of work required to remove the last vestiges of streaks and shadows. The U.S. engineers, naval shipyards, highway departments, and the SSPC have found that there are many applications in which these traces can be tolerated without appreciable loss in coating life. Therefore the need for a grade of blast cleaning beyond that of commercial but less than White-Metal Blast Cleaning was demonstrated. This Near-White Blast Cleaning specification was developed to fill this need.

Near-White Blast Cleaning should be employed for all general purposes where a high degree of blast cleaning is required. It will remove all rust, mill scale, and other detrimental matter from the surface but permits streaks and stains to remain. The surface will not necessarily be completely uniform in color, nor will all surfaces be uniformly clean. However, it is explicit in this specification that shadows, streaks, or discolorations, if any, be slight and be distributed uniformly over the surface — not concentrated in spots or areas.

The advantage of Near-White Blast Cleaning lies in the lower cost for surface preparation that is satisfactory for all but the most severe service conditions. Depending upon the initial condition of the new or previously painted steel, it has been variously estimated that Near-White Blast Cleaning can be carried out at a cost of 10-35% less than that of White Metal Blast Cleaning. These numbers are estimates only and will not hold true in all cases.

The verbal description, calling for at least 95% of the surface being equivalent to White Metal Blast Cleaning, is based upon a large number of visual observations and a limited number of light reflectivity measurements. It is hoped that the amount of surface impurity can be quantified by specific measurement technique, but efforts to date have been unsuccessful except on a laboratory basis. It is believed, however, that a visual estimate of the amount of residuals can be agreed upon between owner and contractor.

When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned in accordance with this specification and the amount of spot cleaning required. In maintenance painting it is not ordinarily intended that sound, adherent old paint be removed unless it is excessively thick, inflexible, or incompatible with the specified paint system. SSPC-PA 1, "Shop, Field and Maintenance Painting," and SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," cover additional maintenance painting procedures.

11.10.1 Visual Standards: If mutually agreed upon, SSPC-Vis 1 or other visual references may be used in place to supplement the cleaning criteria of this specification. For partially rusted mill scale, for completely rusted mill scale, or for completely rusted and pitted surfaces, the appearance of the surface after Near-White Blast Cleaning should correspond to pictorial standards A Sa 2-1/2, B Sa 2-1/2, C Sa 2-1/2, or D Sa 2-1/2 of SSPC-Vis 1. The color or hue of the cleaned surface may be affected by the nature of the steel, abrasives used, and by previous painting. Other cleaning specifications and visual standards are described in Sections 7 and 12 of this Commentary.

11.10.2 As with all SSPC specifications, the referenced standards in effect on the date of invitation to bid shall govern unless otherwise specified.

12. Other Cleaning Specifications

The recommendations, specifications, and guides of a number of other associations reference the Steel Structures Painting Council Surface Preparation Specifications, including: American Association of State Highway and Transportation Officials (AASHTO); American Institute of Steel Construction (AISC); American Iron and Steel Institute (AISI); American Petroleum Institute (API); American Railway Bridge and Building Association (ARBBA); American Water Works Association (AWWA); Canadian Institute of Steel Construction (CISC); Painting and Decorating Contractors of America (PDCA); Steel Plate Fabricators Association (SPFA); and the Texas Structural Steel Institute (TSSI). They are also used by many state highway departments and other federal, state, and local agencies.

The National Association of Corrosion Engineers (NACE) has cooperated closely with the SSPC and in the NACE standards TM-01-70 and TM-01-75 has adopted definitions essentially the same as those given in the definition sections of the four corresponding SSPC surface preparation specifications. Visual standard panels are included in TM-01-70 and TM-01-75 which show each of the four grades of cleaning on surfaces which have been air blasted with sand and centrifugal wheel blasted with cast steel shot and grit.

Governmental agencies have been active in preparing good surface preparation specifications, but most of these deal with thin metal and do not particularly apply to structures. The Corps of Engineers Civil Works Division has issued CW 09940, "Guide Specifications for Painting Hydraulic Structures and Appurtenant Works." This specification covers the cleaning and treating of structural steel as well as the application of paint and the paints to be used. It makes use of the SSPC surface preparation specifications.

Federal Specification TT-C-490, "Cleaning Methods and Pretreatment of Ferrous Surfaces for Organic Coatings," covers various types of surface preparation and pretreatments.

U.S. Military Specification MIL-T-704, "Treatment and Painting (for Construction and Engineering Equipment)," gives detailed instructions for surface preparation of steel, corrosion-resistant steel, zinc, aluminum and aluminum alloys, magnesium alloys, and wood.

For internal use, the U.S. Department of the Navy, Naval Sea Systems Command, has prepared Chapter 631, "Preservation of Ships in Service (Surface Preparation and Painting) NAVSEA-S9086-VD-STM-000C/H-631," which includes surface preparation specifications in addition to painting specifications and paint systems. Detailed specifications for pickling are included.

The British Standards Institution has adopted three grades of blast cleaning roughly equivalent to SSPC-SP 5, 6, and 10. The Swedish Standards Institution has adopted a set of photographs SIS 05 59 00 upon which SSPC-Vis 1 is based. Several of these photographs were provided by the SSPC.

The International Organization for Standardization (ISO) is planning a set of surface preparation definitions and photographic references.

Steel Structures Painting Council
GUIDE TO VISUAL STANDARD NO. 1
Guide to Pictorial Surface Preparation Standards for Painting Steel Surfaces

The pictorial standard, Vis 1, described below was prepared by the Swedish IVA Corrosion Committee with input from the Steel Structures Painting Council and has been jointly approved by the Steel Structures Painting Council, the American Society for Testing and Materials, and the Swedish Standards Association. Copies of the pictorial standard can be obtained from any one of these three associations.

1. Scope

1.1 This guide *only describes* the pictorial standard and does not constitute the standard. The pictorial standard when used in conjunction with the SSPC surface preparation specifications gives only an approximation of the final surface condition. These visual standards should be considered a supplement to, and not a substitute for, surface preparation specifications.

2. Description

2.1 The pictorial surface preparation standard consists of a series of color prints which represent various conditions of unpainted steel surfaces prior to and after surface preparation.

2.2 The standard illustrates four initial rustgrades before surface preparation and covers the range from intact mill scale to badly rusted and pitted steel. These rustgrades are:

A Steel surface covered completely with adherent mill scale with little, if any, rust.

B Steel surface which has begun to rust, and from which the mill scale has begun to flake.

C Steel surface from which the mill scale has rusted away or from which it can be scraped, but with little pitting visible.

D Steel surface on which the mill scale has rusted away and where pitting is visible.

2.3 The standard also illustrates surfaces prepared by hand tool, power tool, and blast cleaning. The various grades of thoroughness of surface preparation are represented in Table 1. This table also shows the approximate correlation between the SSPC surface preparation specifications and the photographic standard, SSPC-Vis 1. For each of the four rustgrades defined, the standard addresses six degrees of cleanliness. The first two degrees are designated "St" for hand and power tool cleaning while the last four are designated "Sa" for blast cleaning.

2.4 Steel surfaces will show variations in shades, color, tone, pitting, flaking, mill scale, etc. These variations should be considered and compensated for when making comparison with the photographic standard.

2.5 This pictorial standard should not be used as a substitute for complete surface preparation specifications, since it is based upon appearance only and does not attempt to deal with other necessary factors such as surface profile, removal of contaminants, degree of removal of rust or impurities, permissible cleaning procedures, equipment, rust back, etc.

3. Procedures

3.1 Select the photograph(s) of unprepared surfaces (A, B, C, or D) that most closely represent(s) the appearance of the steel to be cleaned. NOTE: Occasionally the material to be cleaned will contain more than one of the initial surface conditions.

3.2 Determine the method of surface preparation that is specified (e.g., hand tool cleaning — SSPC-SP 2, white metal blast cleaning — SSPC-SP 5, etc.).

3.3 Use Table 1 to determine which photograph depicts the finished surface. For example, if the initial surface condition is rusted (C) and commercial blast cleaning (SSPC-SP 6) is specified, use photograph C Sa 2.

3.4 Compare the prepared surface with the photograph selected in Section 3.3 to evaluate the cleaning. NOTE: Steel surfaces will show variances in color, shading, etc., both before and after cleaning. Therefore *the photographs can be used only as a guide* and one can not expect an exact correlation when comparing a photograph to the surface.

4. Inspection

4.1 When this guide is used as part of a specification or procurement document, all work supplied shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

TABLE 1

Degee of Cleaning	Adherent Mill Scale A	Rusting Mill Scale B	Rusted C	Pitted and Rusted D
Initial Surface Condition	A Sa 0	B St 0 B Sa 0	C St 0 C Sa 0	D St 0 D Sa 0
Manual Cleaning: Thorough Hand Tool Cleaning SSPC-SP 2	(1)	B St 2	C St 2	D St 2
Manual Cleaning: Very Thorough Power Tool Cleaning SSPC-SP 3	(1)	B St 3	C St 3	D St 3
Blast Cleaning: Light Brush-Off Blast Cleaning SSPC-SP 7	(1)	B Sa 1	C Sa 1	D Sa 1
Blast Cleaning: Thorough Commercial Blast Cleaning SSPC-SP 6	(1)	(2)	C Sa 2	D Sa 2
Blast Cleaning: Very Thorough Near-White Blast Cleaning SSPC-SP 10	A Sa 2-1/2	B Sa 2-1/2	C Sa 2-1/2	D Sa 2-1/2
Blast Cleaning: Extremely Thorough (3) White Metal Blast Cleaning SSPC-SP 5	A Sa 3	B Sa 3	C Sa 3	D Sa 3

(1) No photograph available.

(2) The photograph (through the 1982 printing) corresponding with "B Sa 2" shows dark areas that could be interpreted as millscale and is not recommended as an illustration of SSPC-SP 6, "Commercial Blast Cleaning."

(3) The photographs (1978 through 1982 printing) illustrating "A Sa 3," "B Sa 3," and "C Sa 3" do not adequately illustrate the surface texture of typically blast-cleaned steel.

4.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

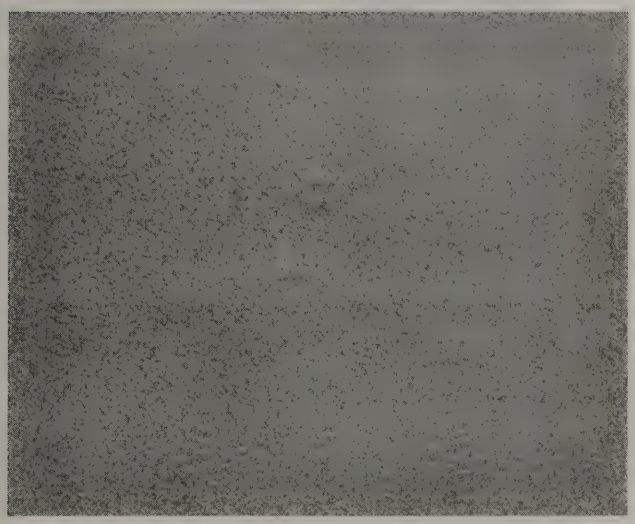
5. Notes

5.1 While every precaution is taken to insure that all information furnished in SSPC guides is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility nor incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the guide itself.

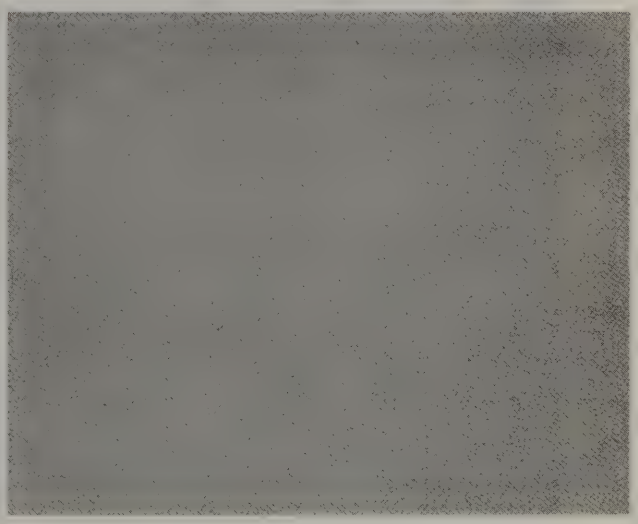
RUST GRADE C—RUSTED

C Sa 1
Brush-Off

C Sa 2½
Near-White



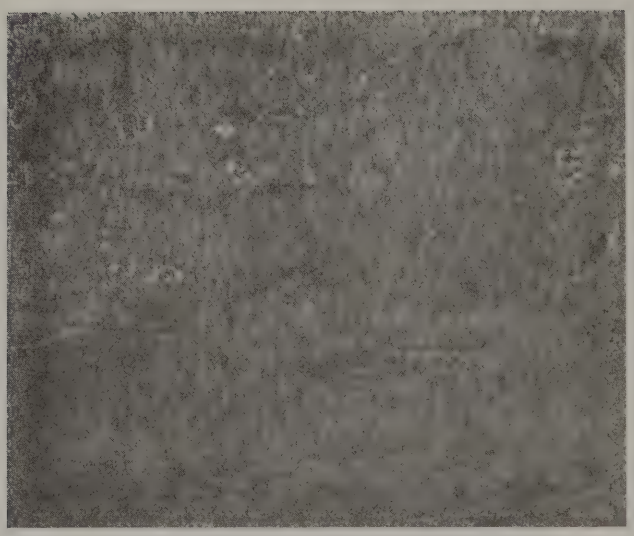
C Sa 2
Commercial



C Sa 3
White Metal

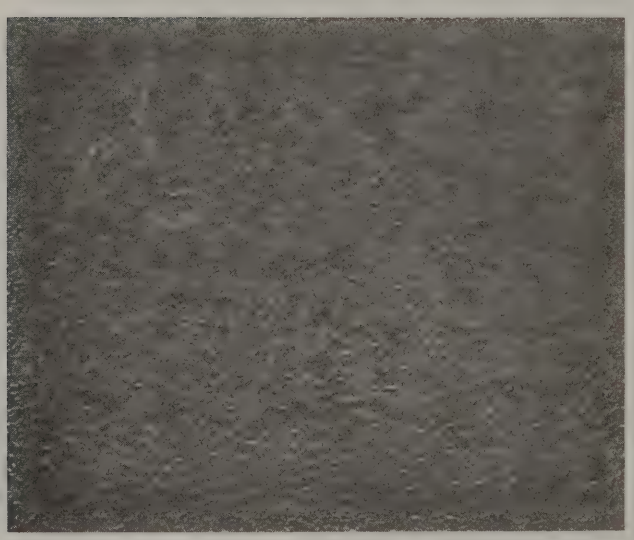
Note: These color reproductions may not be representative of the colors in the standard booklet. They are shown only for illustrative purposes. The standard booklet contains equivalent photographs for Rust Grades A,B, and D, as well as for wire-brushed steel.

RUST GRADES



A
Adherent Mill Scale

C
Rusted



B
Rusting Mill Scale

D
Pitted & Rusted

Note: These color reproductions may not be representative of the colors in the standard booklet. They are shown only for illustrative purposes.

Steel Structures Painting Council
GUIDE TO VISUAL STANDARD NO. 2
Guide to Standard Method of Evaluating Degree of Rusting on Painted Steel Surfaces

The pictorial standard, SSPC-Vis 2, described below was prepared by the American Society for Testing and Materials with input from the Steel Structures Painting Council and has been jointly approved by both organizations. Copies of the pictorial standard can be obtained from either of these associations.

1. Scope

1.1 This guide *only describes* the pictorial standard and does not constitute the standard. It is to be used for comparative purposes and is not intended to have a direct relationship to a decision regarding painting requirements.

2. Description

2.1 The pictorial rusting standard consists of a series of color photographs that represent various amounts of visible rusting on painted steel surfaces.

2.2 The standard illustrates four levels of rusting on painted steel surfaces that range from 0.03% to 10% rust. These levels correspond to rust grades of 9, 8, 6, and 4.

2.3 The rust grading scale ranges from 10 (no rusting or less than 0.01% rusted) to 0 (100% rusted). This numerical rust grade scale is an exponential function of the amount of rust and is described in Table 1. Note that initial slight rusting has the largest effect on lowering the rust grade.

2.4 The pictorial representations of Figure 1 show examples of area percentages which may be helpful in rust grading painted steel surfaces.

3. Procedures

3.1 Surface staining by rust, accumulated dirt, or dirt containing iron or iron compounds should not be confused with the actual rusting involved.

3.2 In evaluating surfaces, consideration should be given to the color of the finish coating, since failures will be more apparent on a finish that shows color contrast with rust such as used in the photographic standards, than on a similar color, such as an iron oxide colored finish.

3.3 Coating failure is likely to vary over a given area. Therefore, discretion should be used when selecting a single grade that is to be representative of a large area or structure.

3.4 The photographic reference standards are not required when estimating the level of rusting since the rust grade scale is based upon the percent of the area rusted. Any method of assessing area rusted (including Figure 1) may be used to determine the rust grade.

3.5 This standard may be projected to include blistering beneath the paint by including the blistered area as if it were rust.

4. Notes

4.1 While every precaution is taken to insure that all information furnished in SSPC guides is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the guide itself.

TABLE 1
DESCRIPTION OF RUST GRADE

Rust Grades	Description	Photographic Standard
10	no rusting or less than 0.01% of of surface rusted	unnecessary
9	minute rusting, less than 0.03% of surface rusted	No. 9
8	few isolated rust spots, less than 0.1% of surface rusted	No. 8
7	less than 0.3% of surface rusted	none
6	extensive spots but less than 1% of surface rusted	No. 6
5	rusting to the extent of 3% of surface rusted	none
4	rusting to the extent of 10% of surface rusted	No. 4
3	approximately one-sixth of the surface rusted	none
2	approximately one-third of the surface rusted	none
1	approximately one-half of the surface rusted	none
0	approximately 100% of the surface rusted	unnecessary

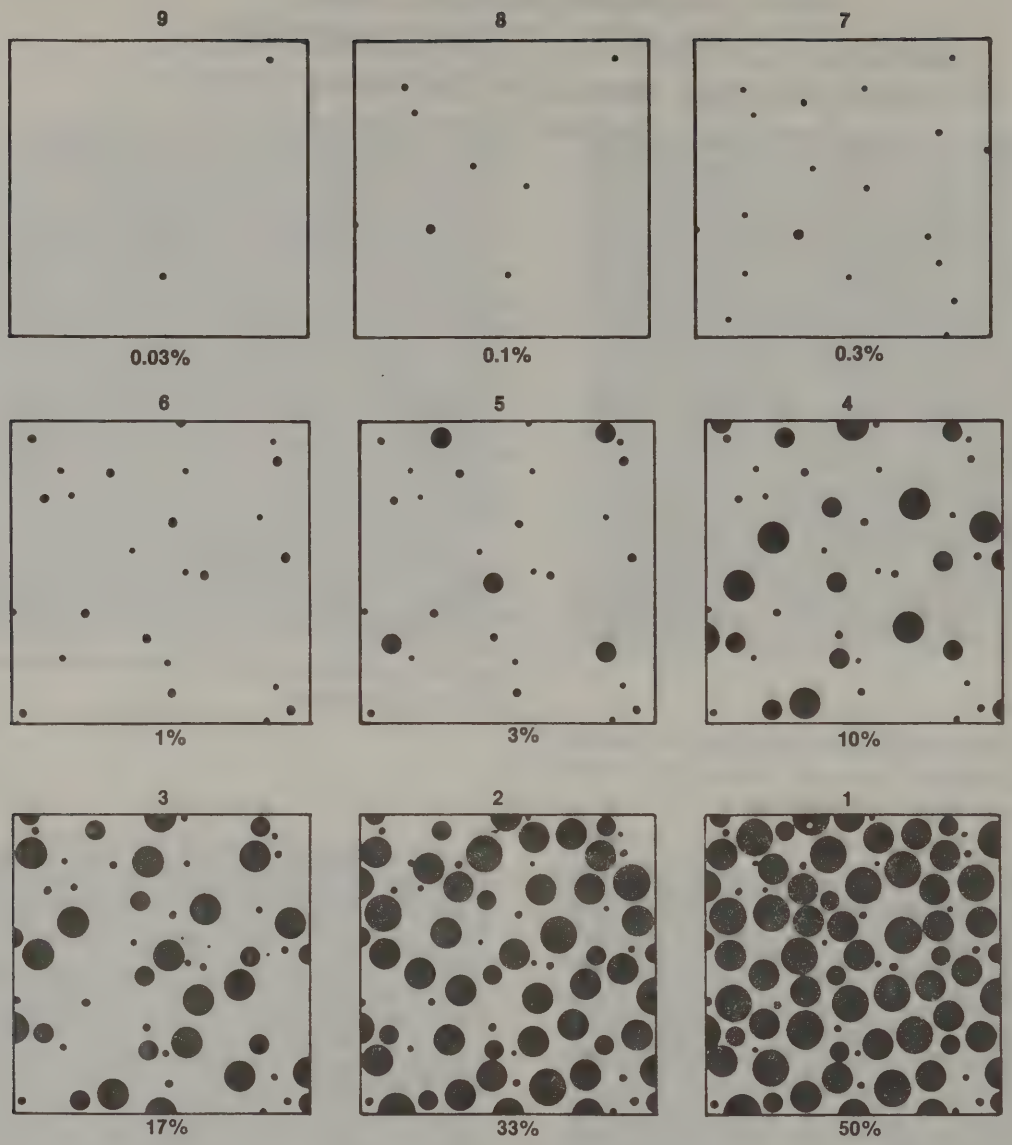


FIGURE 1
Diagrams Representing Rust Grades and the Corresponding Area Percentages

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 1
Solvent Cleaning

1. Scope

1.1 This specification covers the requirements for the solvent cleaning of steel surfaces.

2. Definition

2.1 Solvent cleaning is a method for removing all visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants from steel surfaces.

2.2 It is intended that solvent cleaning be used prior to the application of paint and in conjunction with surface preparation methods specified for the removal of rust, mill scale, or paint.

3. Surface Preparation Before and After Solvent Cleaning

3.1 Prior to solvent cleaning, remove foreign matter (other than grease and oil) by one or a combination of the following: brush with stiff fiber or wire brushes, abrade, scrape, or clean with solutions of appropriate cleaners, provided such cleaners are followed by a fresh water rinse.

3.2 After solvent cleaning, remove dirt, dust, and other contaminants from the surface prior to paint application. Acceptable methods include brushing, blow off with clean, dry air, or vacuum cleaning.

4. Methods of Solvent Cleaning

4.1 Remove heavy oil or grease first by scraper. Then remove the remaining oil or grease by any of the following methods:

4.1.1 Wipe or scrub the surface with rags or brushes wetted with solvent. Use clean solvent and clean rags or brushes for the final wiping.

4.1.2 Spray the surface with solvent. Use clean solvent for the final spraying.

4.1.3 Vapor degrease using stabilized chlorinated hydrocarbon solvents.

4.1.4 Immerse completely in a tank or tanks of solvent. For the last immersion, use solvent which does not contain detrimental amounts of contaminant.

4.1.5 Emulsion or alkaline cleaners may be used in place of the methods described. After treatment, wash the surface with fresh water or steam to remove detrimental residues.

4.1.6 Steam clean, using detergents or cleaners and follow by steam or fresh water wash to remove detrimental residues.

5. Inspection

5.1 All work and materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this specification. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

5.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

6. Safety

6.1 All safety requirements stated in this specification and its component parts apply in addition to any applicable federal, state, and local rules and requirements. They also shall be in accord with instructions and requirements of insurance underwriters.

7. Notes

7.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

7.2 A Commentary Section is available (Chapter 2 of Volume 2 of the Steel Structures Painting Manual) and contains additional information and data relative to this specification. The Surface Preparation Commentary, SSPC-SP COM, is not part of this specification. The table below lists the subjects discussed relevant to solvent cleaning and appropriate Commentary Section.

Subject	SSPC-SP COM Section
Solvents and Cleaners	11.1 through 11.1.3
Steam Cleaning	11.1.4
Threshold Limit Values	11.1.5
Film Thickness	10

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 2
Hand Tool Cleaning

1. Scope

1.1 This specification covers the requirements for the hand tool cleaning of steel surfaces.

2. Definitions

2.1 Hand tool cleaning is a method of preparing steel surfaces by the use of non-power hand tools.

2.2 Hand tool cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

2.3 SSPC-Vis 1 or other visual standards of surface preparation agreed upon by the contracting parties may be used to further define the surface.

3. Reference Standards

3.1 The standards referenced in this specification are listed in Section 3.4 and form a part of the specification.

3.2 The latest issue, revision, or amendment of the reference standards in effect on the date of invitation to bid shall govern unless otherwise specified.

3.3 If there is a conflict between the requirements of any of the cited reference standards and the specification, the requirements of the specification shall prevail.

3.4 STEEL STRUCTURES PAINTING COUNCIL (SSPC) SPECIFICATIONS:

SP 1	Solvent Cleaning
Vis 1	Pictorial Surface Preparation Standards for Painting Steel Surfaces

4. Surface Preparation Before and After Hand Tool Cleaning

4.1 Before hand tool cleaning, remove visible oil, grease, soluble welding residues, and salts by the methods outlined in SSPC-SP 1.

4.2 After hand tool cleaning and prior to painting, reclean the surface if it does not conform to this specification.

4.3 After hand tool cleaning and prior to painting, remove dirt, dust, or similar contaminants from the surface. Acceptable methods include brushing, blow off with clean, dry air, or vacuum cleaning.

5. Methods of Hand Tool Cleaning

5.1 Use impact hand tools to remove stratified rust (rust scale).

5.2 Use impact hand tools to remove all weld slag.

5.3 Use hand wire brushing, hand abrading, hand scraping, or other similar non-impact methods to remove all loose mill scale, all loose or non-adherent rust, and all loose paint.

5.4 Regardless of the method used for cleaning, if specified in the procurement documents, feather edges of remaining old paint so that the repainted surface can have a reasonably smooth appearance.

5.5 If approved by the owner, use power tools or blast cleaning as a substitute cleaning method for this specification.

6. Inspection

6.1 All work and materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this specification. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

6.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

7. Safety

7.1 All safety requirements stated in this specification and its component parts apply in addition to any applicable federal, state, and local rules and requirements. They also shall be in accord with instructions and requirements of insurance underwriters.

8. Notes

8.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

8.2 A Commentary Section is available (Chapter 2 of Volume 2 of the Steel Structures Painting Manual) and contains additional information and data relevant to this specification. The Surface Preparation Commentary, SSPC-SP COM, is not part of this specification. The table below lists the subjects discussed relevant to hand tool cleaning and appropriate Commentary Section.

	SSPC-SP COM Section
Degree of Cleaning	11
Film Thickness	10
Maintenance Painting	3.2
Rust Back	8
Visual Standards	7
Weld Spatter	4.1

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 3
Power Tool Cleaning

1. Scope

1.1 This specification covers the requirements for the power tool cleaning of steel surfaces.

2. Definition

2.1 Power tool cleaning is a method of preparing steel surfaces by the use of power assisted hand tools.

2.2 Power tool cleaning removes all loose mill scale, loose rust, loose paint, and other loose detrimental foreign matter. It is not intended that adherent mill scale, rust, and paint be removed by this process. Mill scale, rust, and paint are considered adherent if they cannot be removed by lifting with a dull putty knife.

2.3 SSPC-Vis 1 or other visual standards of surface preparation agreed upon by the contracting parties may be used to further define the surface.

3. Reference Standards

3.1 The standards referenced in this specification are listed in Section 3.4 and form a part of the specification.

3.2 The latest issue, revision or amendment of the reference standards in effect on the date of invitation to bid shall govern unless otherwise specified.

3.3 If there is a conflict between the requirements of any of the cited reference standards and the specification, the requirements of the specification shall prevail.

3.4 STEEL STRUCTURES PAINTING COUNCIL (SSPC) SPECIFICATIONS:

SP 1	Solvent Cleaning
Vis 1	Pictorial Surface Preparation Standards for Painting Steel Surfaces

4. Surface Preparation Before and After Power Tool Cleaning

4.1 Before power tool cleaning, remove visible oil, grease, soluble welding residue, and salts by the methods outlined in SSPC-SP 1.

4.2 After power tool cleaning and prior to painting, reclean the surface if it does not conform to this specification.

4.3 After power tool cleaning and prior to painting, remove dirt, dust, or similar contaminants from the surface. Acceptable methods include brushing, blow off with clean, dry air, or vacuum cleaning.

5. Methods of Power Tool Cleaning

5.1 Use rotary or impact power tools to remove stratified rust (rust scale).

5.2 Use rotary or impact power tools to remove all weld slag.

5.3 Use power wire brushing, power abrading, power impact or other power rotary tools to remove all loose mill scale, all loose or non-adherent rust, and all loose paint. Do not burnish the surface.

5.4 Operate power tools in a manner that prevents the formation of burrs, sharp ridges, and sharp cuts.

5.5 Regardless of the method used for cleaning, if specified in the procurement documents, feather edges of remaining old paint so that the repainted surface can have a reasonably smooth appearance.

5.6 If approved by the owner, use blast cleaning as a substitute cleaning method for this specification.

6. Inspection

6.1 All work and materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this specification. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

6.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

7. Safety

7.1 All safety requirements stated in this specification and its component parts apply in addition to any applicable federal, state, and local rules and requirements. They also shall be in accord with instructions and requirements of insurance underwriters.

8. Notes

8.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

8.2 A Commentary Section is available (Chapter 2 of Volume 2 of the Steel Structures Painting Manual) and contains additional information and data relevant to this specification. The Surface Preparation Commentary, SSPC-SP COM, is not part of this specification. The table below lists the subjects discussed relevant to power tool cleaning and appropriate Commentary Section.

	SSPC-SP COM Section
Degree of Cleaning	11
Film Thickness	10
Maintenance Painting	3.2
Rust Back	8
Visual Standards	7
Weld Spatter	4.1

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 5
White Metal Blast Cleaning

1. Scope

1.1 This specification covers the requirements for White Metal Blast Cleaning of steel surfaces by the use of abrasives.

2. Definition

2.1 A White Metal Blast Cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter.

2.2 ACCEPTABLE VARIATIONS IN APPEARANCE THAT DO NOT AFFECT SURFACE CLEANLINESS as defined in Section 2.1 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasive, and differences in the blast pattern.

2.3 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system.

2.4 Immediately prior to paint application the surface shall comply with the degree of cleaning as specified herein.

2.5 SSPC-Vis 1 or other visual standards of surface preparation may be specified to supplement the written definition.
*NOTE: Additional information on visual standards is available in section A.4 of the Appendix.

3. Blast Cleaning Abrasives

3.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, type of blast cleaning system employed, the finished surface to be produced (cleanliness and roughness), and whether the abrasive will be recycled.

3.2 The cleanliness and size of recycled abrasives shall be maintained to insure compliance with this specification.

3.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other harmful materials at the time of use.

3.4 Any limitations or restrictions on the use of specific abrasives, quantity of contaminants, or degree of embedment shall be included in the procurement documents (project specification) covering the work, since abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements.
*NOTE: Additional information on abrasive selection is available in Section A.2 of the Appendix.

*Notes are not requirements of this specification.

4. Reference Standards

4.1 If there is a conflict between the cited reference standards and this specification, this specification shall prevail unless otherwise indicated in the procurement documents (project specification).

4.2 The standards referenced in this specification are:

SSPC-SP 1	Solvent Cleaning
SSPC-Vis 1	Pictorial Surface Preparation Standards for Painting Steel Surfaces

5. Procedure Before Blast Cleaning

5.1 Before blast cleaning, visible deposits of oil or grease shall be removed by any of the methods specified in SSPC-SP 1 or other agreed upon methods.

5.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification).
*NOTE: Additional information on surface imperfections is available in Section A.5 of the Appendix.

6. Blast Cleaning Methods and Operation

6.1 Clean, dry, compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps or other equipment may be necessary to achieve this requirement.

6.2 Any of the following methods of surface preparation may be used to achieve a White Metal Blast Cleaned surface:

6.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

6.2.2 Dry abrasive blasting using a closed cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and

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abrasive recovery.

6.2.3 Dry abrasive blasting, using a closed cycle, recirculating abrasive system with centrifugal wheels and abrasive.

6.3 Other methods of surface preparation (such as wet abrasive blasting) may be used to achieve a White Metal Blast Cleaned surface by mutual agreement between the party responsible for performing the work and the party responsible for establishing the requirements or his representative.

*NOTE: If wet abrasive blasting is used, information on the use of inhibitors to prevent the formation of rust immediately after wet blast cleaning is contained in Section A.9 of the Appendix.

7. Procedures Following Blast Cleaning and Immediately Prior to Painting

7.1 Visible deposits of oil, grease, or other contaminants shall be removed by any of the methods specified in SSPC-SP 1 or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

7.3 After blast cleaning, surface imperfections which remain (i.e., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers, etc.) shall be removed to the extent required in the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of section 2.3.

*NOTE: Additional information on surface imperfections is contained in Section A.5 of the Appendix.

7.4 Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by reblasting the rusted areas to meet the requirements of this specification before painting.

*NOTE: Information on rust-back (rerusting) and surface condensation is contained in Sections A.7 and A.8 of the Appendix.

8. Inspection

8.1 Work and materials supplied under this specification are subject to inspection by the party responsible for establishing the requirements or his representative. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be as agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

8.2 Conditions not complying with this specification shall be corrected. In case of dispute the arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then the procedure established by the American Arbitration Association shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Safety and Environmental Requirements

9.1 Blast cleaning is a hazardous operation. Therefore, all work shall be conducted in such a manner to comply with all applicable insurance underwriter, local, state, and federal safety and environmental rules and requirements.

*NOTE: SSPC-PA Guide 3, "A Guide to Safety in Paint Application," addresses safety concerns for coating work.

10. Comments

10.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the Steel Structures Painting Council cannot assume responsibility nor incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

10.2 Additional information and data relative to this specification are contained in the following brief Appendix. More detailed information and data are presented in a separate document, SSPC-SP COM, "Surface Preparation Commentary." The recommendations contained in the Notes, Appendix, and SSPC-SP COM are believed to represent good practice, but are not to be considered as requirements of the specification. The table below lists the subjects discussed relevant to White Metal Blast Cleaning and appropriate section of SSPC-SP COM.

Subject	Commentary Section
Abrasive Selection	5.
Degree of Cleaning	11.5
Film Thickness	10.
Wet Abrasive Blast Cleaning	9.
Maintenance Painting	3.2
Rust Back (Rerusting)	8.
Surface Profile	6.
Visual Standards	7.
Weld Spatter	4.1

A. Appendix

A.1 FUNCTION — White Metal Blast Cleaning (SSPC-SP 5) provides a greater degree of cleaning than Near-White Blast Cleaning (SSPC-SP 10). It should be used where the highest degree of blast cleaning is required. The primary functions of blast cleaning before painting are: (a) to remove material from the surface that can cause early failure of the coating system, and (b) to obtain a suitable surface roughness.

A.2 ABRASIVE SELECTION — Types of metallic and non-metallic abrasives are discussed in the Surface Preparation Commentary (SSPC-SP COM). It is important to recognize that blasting abrasives may become embedded in or leave residues on the surface of the steel during preparation. While normally such embedment or residues are not detrimental, care should be taken (particularly if the prepared steel is to be used in an immersion environment) to assure that the abrasive is free from detrimental amounts of water soluble, solvent soluble, acid soluble, or other such soluble materials.

A.3 SURFACE PROFILE — Surface profile is the roughness of the surface which results from abrasive blast cleaning. The profile depth (or height) is dependent upon the size, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent upon the thickness of the paint to be applied. Large particle sized abrasives (particularly metallic) can produce a profile which may be too deep to be adequately covered by a single thin film coat. Accordingly, it is recommended that the use of larger abrasives be avoided in these cases. However, larger abrasives may be needed for thick film coatings or to facilitate removal of heavy mill scale or rust. If control of profile (minimum/maximum) is deemed to be significant to coatings performance, it should be addressed in the procurement documents (project specification).

Typical maximum profile heights achieved with commercial abrasive media are shown in Table 8 of the Surface Preparation Commentary (SSPC-SP COM). Methods (i.e., comparators, replica tape, depth micrometers) are available to aid in estimating the profile of surfaces blast cleaned with sand, steel grit, and steel shot.

A.4 VISUAL STANDARDS — Note that the use of visual standards in conjunction with this specification is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents (project specification)

SSPC-Vis 1, "Pictorial Surface Preparation Standards for Painting Steel Surfaces," provides color photographs for the various grades of surface preparation as a function of the initial condition of the steel. The following table lists the pictorial standards for this specification that are applicable to the rust grades given.

Rust Grade	Adherent Mill Scale	Rusting Mill Scale	Rusted	Pitted and Rusted
Pictorial Standards	A Sa 3	B Sa 3	C Sa 3	D Sa 3

Many other visual standards are available and are described in Section 7 of the Commentary (SSPC-SP COM).

A.5 SURFACE IMPERFECTIONS — Surface imperfections can cause premature failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features which are difficult to properly cover and protect include crevices, weld porosity, laminations, etc. The high cost of the methods to remedy the surface imperfections requires weighing the benefits of edge rounding, weld spatter removal, etc., versus a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work is essential since the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4 of the Commentary (SSPC-SP COM) contains additional information on surface imperfections.

A.6 CHEMICAL CONTAMINATION — Steel contaminated with soluble salts (i.e., chlorides and sulfates) develops rust-back rapidly at intermediate and high humidities. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be deposited on the steel surface during blast cleaning whenever the abrasive is contaminated. Therefore, rust-back can be minimized by removing these salts from the steel surface, preferably before blast cleaning, and eliminating sources of recontamination during and after blast cleaning. Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests. A number of tests for soluble salts are now under study by the SSPC, ASTM, Maritime Administration, and ISO.

A.7 RUST-BACK — Rust-back (rerusting) occurs when freshly cleaned steel is exposed to conditions of high

humidity, moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back will vary greatly from one environment to another. Under mild ambient conditions it is best to blast clean and coat a surface the same day. Severe conditions may require coating more quickly while for exposure under controlled conditions the coating time may be extended. Under no circumstances should the steel be permitted to rust-back before painting regardless of the time elapsed (see Appendix A.6).

A.8 DEW POINT — Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is, therefore, recommended that the temperature of steel surface be at least 5 degrees F (3 degrees C) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is important that the application of paint over a damp surface be avoided.

A.9 WET ABRASIVE BLAST CLEANING — Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing (studies have shown that water of at least 15,000 ohm-cm resistivity is preferred). It may be necessary that inhibitors be added to the water or applied to the surface immediately after blast cleaning to temporarily prevent rust formation. The coating should then be applied before any rusting is visible. One inhibitive treatment for blast cleaned surfaces is water containing 0.32% sodium nitrite and 1.28% by weight secondary ammonium phosphate (dibasic).
CAUTION: Some inhibitive treatments may interfere with the performance of certain coating systems.

A.10 FILM THICKNESS — It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or failure will occur. To assure that coating thicknesses are properly measured, refer to SSPC-PA 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

A.11 MAINTENANCE AND REPAIR PAINTING — When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," provides a description of accepted practices for retaining old sound paint, removing unsound paint, feathering, and spot cleaning.

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 6
Commercial Blast Cleaning

1. Scope

1.1 This specification covers the requirements for Commercial Blast Cleaning of steel surfaces by the use of abrasives.

2. Definition

2.1 A Commercial Blast Cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except for staining, as noted in Section 2.2.

2.2 Staining shall be limited to no more than 33 percent of each square inch of surface area and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied paint. Slight residues of rust and paint may also be left in the bottoms of pits if the original surface is pitted.

2.3 ACCEPTABLE VARIATIONS IN APPEARANCE THAT DO NOT AFFECT SURFACE CLEANLINESS as defined in Sections 2.1 and 2.2 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasive, and differences in the blast pattern.

2.4 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system.

2.5 Immediately prior to paint application, the surface shall comply with the degree of cleaning as specified herein.

2.6 SSPC-Vis 1 or other visual standards of surface preparation may be specified to supplement the written definition.
*NOTE: Additional information on visual standards is available in Section A.4 of the Appendix.

3. Blast Cleaning Abrasives

3.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, type of blast cleaning system employed, the finished surface to be produced (cleanliness and roughness), and whether the abrasive will be recycled.

3.2 The cleanliness and size of recycled abrasives shall be maintained to insure compliance with this specification.

3.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other harmful materials at the time of use.

3.4 Any limitations or restrictions on the use of specific abrasives, quantity of contaminants, or degree of embedment shall be included in the procurement documents (project specification) covering the work, since abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements.
*NOTE: Additional information on abrasive selection is available in Section A.2 of the Appendix.

4. Reference Standards

4.1 If there is a conflict between the cited reference standards and this specification, this specification shall prevail unless otherwise indicated in the procurement documents (project specification).

4.2 The standards referenced in this specification are:

SSPC-SP 1	Solvent Cleaning
SSPC-Vis 1	Pictorial Surface Preparation Standards for Painting Steel Surfaces

5. Procedure Before Blast Cleaning

5.1 Before blast cleaning, visible deposits of oil or grease shall be removed by any of the methods specified in SSPC-SP 1 or other agreed upon methods.

5.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification).
*NOTE: Additional information on surface imperfections is available in Section A.5 of the Appendix.

6. Blast Cleaning Methods and Operation

6.1 Clean, dry, compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps or other equipment may be necessary to achieve this requirement.

*Notes are not requirements of this specification.

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6.2 Any of the following methods of surface preparation may be used to achieve a Commercial Blast Cleaned surface:

6.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

6.2.2 Dry abrasive blasting using a closed cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

6.2.3 Dry abrasive blasting, using a closed cycle, recirculating abrasive system with centrifugal wheels and abrasive.

6.3 Other methods of surface preparation (such as wet abrasive blasting) may be used to achieve a Commercial Blast Cleaned surface by mutual agreement between the party responsible for performing the work and the party responsible for establishing the requirements or his representative.
*NOTE: If wet abrasive blasting is used, information on the use of inhibitors to prevent the formation of rust immediately after wet blast cleaning is contained in Section A.9 of the Appendix.

7. Procedures Following Blast Cleaning and Immediately Prior to Painting

7.1 Visible deposits of oil, grease, or other contaminants shall be removed by any of the methods specified in SSPC-SP 1 or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

7.3 After blast cleaning, surface imperfections which remain (i.e., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers, etc.) shall be removed to the extent required in the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of Section 2.4.
*NOTE: Additional information on surface imperfections is contained in Section A.5 of the Appendix.

7.4 Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by reblasting the rusted areas to meet the requirements of this specification before painting.
*NOTE: Information on rust-back (rerusting) and surface condensation is contained in Sections A.7 and A.8 of the Appendix.

8. Inspection

8.1 Work and materials supplied under this specification are subject to inspection by the party responsible for establishing the requirements or his representative. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be as agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

8.2 Conditions not complying with this specification shall be corrected. In case of dispute the arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then the procedure established by the American Arbitration Association shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Safety and Environmental Requirements

9.1 Blast cleaning is a hazardous operation. Therefore, all work shall be conducted in such a manner to comply with all applicable insurance underwriter, local, state, and federal safety and environmental rules and requirements.
*NOTE: SSPC-PA Guide 3, "A Guide to Safety in Paint Application," addresses safety concerns for coating work.

10. Comments

10.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the Steel Structures Painting Council cannot assume responsibility nor incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

10.2 Additional information and data relative to this specification are contained in the following brief Appendix. More detailed information and data are presented in a separate document, SSPC-SP COM, "Surface Preparation Commentary." The recommendations contained in the Notes, Appendix, and SSPC-SP COM are believed to represent good practice, but are not to be considered as requirements of the specification. The table below lists the subjects discussed relevant to Commercial Blast Cleaning and appropriate section of SSPC-SP COM.

Subject	Commentary Section
Abrasive Selection	5.
Degree of Cleaning	11.6
Film Thickness	10.
Wet Abrasive Blast Cleaning	9.
Maintenance Painting	3.2
Rust Back (Rerusting)	8.
Surface Profile	6.
Visual Standards	7.
Weld Spatter	4.1

A. Appendix

A.1 FUNCTION — Commercial Blast Cleaning (SSPC-SP 6) provides a greater degree of cleaning than Brush-Off Blast Cleaning (SSPC-SP 7) but less than Near-White Blast Cleaning (SSPC-SP 10). It should be used where a high but not perfect degree of blast cleaning is required. The primary functions of blast cleaning before painting are: (a) to remove material from the surface that can cause early failure of the coating system, and (b) to obtain a suitable surface roughness.

A.2 ABRASIVE SELECTION — Types of metallic and non-metallic abrasives are discussed in the Surface Preparation Commentary (SSPC-SP COM). It is important to recognize that blasting abrasives may become embedded in or leave residues on the surface of the steel during preparation. While normally such embedment or residues are not detrimental, care should be taken (particularly if the prepared steel is to be used in an immersion environment) to assure that the abrasive is free from detrimental amounts of water soluble, solvent soluble, acid soluble, or other such soluble materials.

A.3 SURFACE PROFILE — Surface profile is the roughness of the surface which results from abrasive blast cleaning. The profile depth (or height) is dependent upon the size, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent upon the thickness of the paint to be applied. Large particle sized abrasives (particularly metallic) can produce a profile which may be too deep to be adequately covered by a single thin film coat. Accordingly, it is recommended that the use of larger abrasives be avoided in these cases. However, larger abrasives may be needed for thick film coatings or to facilitate removal of heavy mill scale or rust. If control of profile (minimum/maximum) is deemed to be significant to coatings performance, it should be addressed in the procurement documents (project specification).

Typical maximum profile heights achieved with commercial abrasive media are shown in Table 8 of the Surface Preparation Commentary (SSPC-SP COM). Methods (i.e., comparators, replica tape, depth micrometers) are available to aid in estimating the profile of surfaces blast cleaned with sand, steel grit, and steel shot.

A.4 VISUAL STANDARDS — Note that the use of visual standards in conjunction with this specification is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents (project specification).

SSPC-Vis 1, "Pictorial Surface Preparation Standards for Painting Steel Surfaces," provides color photographs for the various grades of surface preparation as a function of the initial condition of the steel. The following table lists the pictorial standards for this specification that are applicable to the rust grades listed below.

Rust Grade	Rusted	Pitted and Rusted
Pictorial Standards	C Sa 2	D Sa 2

Many other visual standards are available and are described in Section 7 of the Commentary (SSPC-SP COM).

A.5 SURFACE IMPERFECTIONS — Surface imperfections can cause premature failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features which are difficult to properly cover and protect include crevices, weld porosity, laminations, etc. The high cost of the methods to remedy the surface imperfections requires weighing the benefits of edge rounding, weld spatter removal, etc., versus a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work is essential since the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4 of the Commentary (SSPC-SP COM) contains additional information on surface imperfections.

A.6 CHEMICAL CONTAMINATION — Steel contaminated with soluble salts (i.e., chlorides and sulfates) develops rust-back rapidly at intermediate and high humidities. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric

contamination. In addition, contaminants can be deposited on the steel surface during blast cleaning whenever the abrasive is contaminated. Therefore, rust-back can be minimized by removing these salts from the steel surface, preferably before blast cleaning, and eliminating sources of recontamination during and after blast cleaning. Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests. A number of tests for soluble salts are now under study by the SSPC, ASTM, Maritime Administration, and ISO.

A.7 RUST-BACK — Rust-back (rerusting) occurs when freshly cleaned steel is exposed to conditions of high humidity, moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back will vary greatly from one environment to another. Under mild ambient conditions it is best to blast clean and coat a surface the same day. Severe conditions may require coating more quickly while for exposure under controlled conditions the coating time may be extended. Under no circumstances should the steel be permitted to rust-back before painting regardless of the time elapsed (see Appendix A.6).

A.8 DEW POINT — Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is, therefore, recommended that the temperature of steel surface be at least 5 degrees F (3 degrees C) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is important that the application of paint over a damp surface be avoided.

A.9 WET ABRASIVE BLAST CLEANING — Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing (studies have shown that water of at least 15,000 ohm-cm resistivity is preferred). It may be necessary that inhibitors be added to the water or applied to the surface immediately after blast cleaning to temporarily prevent rust formation. The coating should then be applied before any rusting is visible. One inhibitive treatment for blast cleaned surfaces is water containing 0.32% sodium nitrite and 1.28% by weight secondary ammonium phosphate (dibasic).
CAUTION: Some inhibitive treatments may interfere with the performance of certain coating systems.

A.10 FILM THICKNESS — It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or failure will occur. To assure that coating thicknesses are properly measured, refer to SSPC-PA 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

A.11 MAINTENANCE AND REPAIR PAINTING — When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," provides a description of accepted practices for retaining old sound paint, removing unsound paint, feathering, and spot cleaning.

Steel Structures Painting Council

SURFACE PREPARATION SPECIFICATION NO. 7
Brush-Off Blast Cleaning

1. Scope

1.1 This specification covers the requirements for Brush-Off Blast Cleaning of steel surfaces by the use of abrasives.

2. Definition

2.1 A Brush-Off Blast Cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, loose mill scale, loose rust, and loose paint. Tightly adherent mill scale, rust, and paint may remain on the surface. Mill scale, rust, and paint are considered tightly adherent if they cannot be removed by lifting with a dull putty knife.

2.2 The entire surface shall be subjected to the abrasive blast. The remaining mill scale, rust, or paint shall be tight.

2.3 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system.

2.4 Immediately prior to paint application, the surface shall comply with the degree of cleaning as specified herein.

2.5 SSPC-Vis 1 or other visual standards of surface preparation may be specified to supplement the written definition.
*NOTE: Additional information on visual standards is available in Section A.4 of the Appendix.

3. Blast Cleaning Abrasives

3.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, type of blast cleaning system employed, the finished surface to be produced (cleanliness and roughness), and whether the abrasive will be recycled.

3.2 The cleanliness and size of recycled abrasives shall be maintained to insure compliance with this specification.

3.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other harmful materials at the time of use.

3.4 Any limitations or restrictions on the use of specific abrasives, quantity of contaminants, or degree of embedment shall be included in the procurement documents (project specification) covering the work, since abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements.
*NOTE: Additional information on abrasive selection is available in Section A.2 of the Appendix.

4. Reference Standards

4.1 If there is a conflict between the cited reference standards and this specification, this specification shall prevail unless otherwise indicated in the procurement documents (project specification).

4.2 The standards referenced in this specification are:

SSPC-SP 1	Solvent Cleaning
SSPC-Vis 1	Pictorial Surface Preparation Standards for Painting Steel Surfaces

5. Procedure Before Blast Cleaning

5.1 Before blast cleaning, visible deposits of oil or grease shall be removed by any of the methods specified in SSPC-SP 1 or other agreed upon methods.

6. Blast Cleaning Methods and Operation

6.1 Clean, dry, compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps or other equipment may be necessary to achieve this requirement.

6.2 Any of the following methods of surface preparation may be used to achieve a Brush-Off Blast Cleaned surface:

6.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

6.2.2 Dry abrasive blasting using a closed cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

6.2.3 Dry abrasive blasting, using a closed cycle, recirculating abrasive system with centrifugal wheels and abrasive.

6.3 Other methods of surface preparation (such as wet abrasive blasting) may be used to achieve a Brush- Off Blast Cleaned surface by mutual agreement between the

*Notes are not requirements of this specification.

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party responsible for performing the work and the party responsible for establishing the requirements or his representative.

*NOTE: If wet abrasive blasting is used, information on the use of inhibitors to prevent the formation of rust immediately after wet blast cleaning is contained in Section A.8 of the Appendix

7. Procedures Following Blast Cleaning and Immediately Prior to Painting

7.1 Visible deposits of oil, grease, or other contaminants shall be removed by any of the methods specified in SSPC-SP 1 or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

8. Inspection

8.1 Work and materials supplied under this specification are subject to inspection by the party responsible for establishing the requirements or his representative. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be as agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

8.2 Conditions not complying with this specification shall be corrected. In case of dispute the arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then the procedure established by the American Arbitration Association shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Safety and Environmental Requirements

9.1 Blast cleaning is a hazardous operation. Therefore, all work shall be conducted in such a manner to comply with all applicable insurance underwriter, local, state, and federal safety and environmental rules and requirements.

*NOTE: SSPC-PA Guide 3, "A Guide to Safety in Paint Application," addresses safety concerns for coating work.

10. Comments

10.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the Steel Structures Painting Council cannot assume responsibility nor incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

10.2 Additional information and data relative to this specification are contained in the following brief Appendix. More detailed information and data are presented in a separate document, SSPC-SP COM, "Surface Preparation Commentary." The recommendations contained in the Notes, Appendix, and SSPC-SP COM are believed to represent good practice, but are not to be considered as requirements of the specification. The table below lists the subjects discussed relevant to Brush-Off Blast Cleaning and appropriate section of SSPC-SP COM.

Subject	Commentary Section
Abrasive Selection	5.
Degree of Cleaning	11.7
Film Thickness	10.
Wet Abrasive Blast Cleaning	9.
Maintenance Painting	3.2
Rust Back (Rerusting)	8.
Surface Profile	6.
Visual Standards	7.
Weld Spatter	4.1

A. Appendix

A.1 FUNCTION — Brush-Off Blast Cleaning (SSPC-SP 7) provides a lesser degree of cleaning than Commercial Blast Cleaning (SSPC-SP 6). It should be used where the service environment is mild enough to permit tight mill scale, paint, rust, and other foreign matter to remain on the surface. The primary functions of blast cleaning before painting are: (a) to remove material from the surface that can cause early failure of the coating system, and (b) to obtain a suitable surface roughness.

A.2 ABRASIVE SELECTION — Types of metallic and non-metallic abrasives are discussed in the Surface Preparation Commentary (SSPC-SP COM).

A.3 SURFACE PROFILE — Surface profile is the roughness of the surface which results from abrasive blast cleaning. The profile depth (or height) is dependent upon the size, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of recycling, and the proper maintenance of working mixtures of grit and/or shot.

A.4 VISUAL STANDARDS — Note that the use of visual standards in conjunction with this specification is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents (project specification).

SSPC-Vis 1, "Pictorial Surface Preparation Standards for Painting Steel Surfaces," provides color photographs for the various grades of surface preparation as a function

of the initial condition of the steel. The following table lists the pictorial standards for this specification that are applicable to the rust grades listed below.

Rust Grade	Rusting Mill Scale	Rusted	Pitted and Rusted
Pictorial Standards	B Sa 1	C Sa 1	D Sa 1

Many other visual standards are available and are described in Section 7 of the Commentary (SSPC-SP COM).

A.5 DEW POINT — Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is, therefore, recommended that the temperature of steel surface be at least 5 degrees F (3 degrees C) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is important that the application of paint over a damp surface be avoided.

A.6 WET ABRASIVE BLAST CLEANING — Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing (studies have shown that water of at least 15,000 ohm-cm resistivity is preferred). It may be necessary that inhibitors be added to the water or applied to the surface immediately after blast cleaning to temporarily prevent rust formation. The coating should then be applied before any rusting is visible. One inhibitive treatment for blast cleaned surfaces is water containing 0.32% sodium nitrite and 1.28% by weight secondary ammonium phosphate (dibasic).
CAUTION: Some inhibitive treatments may interfere with the performance of certain coating systems.

A.7 FILM THICKNESS — It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or failure will occur. To assure that coating thicknesses are properly measured, refer to SSPC-PA 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

A.8 MAINTENANCE AND REPAIR PAINTING — When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," provides a description of accepted practices for retaining old sound paint, removing unsound paint, feathering, and spot cleaning.

Steel Structures Painting Council

SURFACE PREPARATION SPECIFICATION NO. 8
Pickling

1. Scope

1.1 This specification covers the requirements for the pickling of steel surfaces.

2. Definition

2.1 Pickling is a method of preparing steel surfaces by chemical reaction, electrolysis, or both. The surfaces when viewed without magnification shall be free of all visible mill scale and rust.

3. Appearance of the Completed Surface

3.1 The surface shall be etched to a degree suitable for the specified painting system.

3.2 Uniformity of color may be affected by the grade, original surface condition, and configuration of the material being cleaned, as well as by discolorations from mill or fabrication marks, and the shadowing from etching patterns.

3.3 Visual standards of surface preparation agreed upon by the contracting parties may be used to further define the surface.

4. Reference Standards

4.1 The standards referenced in this specification are listed in Section 4.4 and form a part of the specification.

4.2 The latest issue, revision, or amendment of the reference standards in effect on the date of invitation to bid shall govern unless otherwise specified.

4.3 If there is a conflict between the requirements of any of the cited reference standards and the specification, the requirements of the specification shall prevail.

4.4 STEEL STRUCTURES PAINTING COUNCIL (SSPC) SPECIFICATIONS:

SP 1	Solvent Cleaning
SP 2	Hand Tool Cleaning
SP 3	Power Tool Cleaning
SP 6	Commercial Blast Cleaning
SP 7	Brush-Off Blast Cleaning

5. Pickling Methods and Operation

5.1 BEFORE PICKLING, PERFORM THE FOLLOWING:

5.1.1 Remove heavy deposits of oil, grease, soil, drawing compounds, and foreign matter other than rust, scale, or oxide by any of the methods specified in SSPC-SP 1. Small quantities of such foreign matter may be removed in the pickling tanks provided no detrimental residue remains on the surface.

5.1.2 Remove heavy deposits of rust, rust scale, and all paint by any one of the methods specified in SSPC-SP 2, SP 3, SP 6, or SP 7. Rust deposits which can be removed without unduly prolonging the pickling time may be removed in the pickling tanks.

5.2 REMOVE ALL MILL SCALE AND RUST BY ANY OF THE FOLLOWING PICKLING METHODS:

5.2.1 Pickling in hot or cold solutions of sulfuric, hydrochloric (muriatic), or phosphoric acid to which sufficient inhibitor has been added to minimize attack on the base metal, followed by adequate rinsing in hot water above 140° F (60° C).

5.2.2 Pickling in 5%-10% (by weight) sulfuric acid, containing an inhibitor, at a minimum of 140° F (60° C) until all rust and scale is removed; then thorough rinsing in clean water, then immersion for one to five minutes in 1%-2% (by weight) phosphoric acid containing about 0.3%-0.5% iron phosphate, at a temperature of about 180° F (80° C).

5.2.3 Pickling in 5% (by volume) sulfuric acid at 170-180° F (75-80° C), with sufficient inhibitor added to minimize attack on the base metal, until all rust and scale is removed, followed by a two minute rinse in hot water at 170-180° F (75-80° C). Next, immerse the pickled and rinsed steel for at least two minutes in a hot, inhibitive solution maintained above 190° F (85° C) and containing about 0.75% sodium dichromate and about 0.5% orthophosphoric acid.

5.2.4 Electrolytic pickling in an acid or an alkaline bath using alternating or direct current. If (when using direct current) the work-piece is made the cathode, hydrogen embrittlement must be prevented or minimized by adequate treatment. If carried out in an alkaline bath, the electrolytic pickling must be followed by a thorough rinse in hot water; then followed by a dip in a dilute solution of phosphoric acid, or chromic acid, or solution of dichromate until no trace of alkali remains on the surface.

5.2.5 "Hydride" descaling, pickling in baths of acid salts, pickling in baths of molten salts, or pickling in any other manner than outlined in the preceding sections shall be permitted only when specified, since their details are beyond the scope of this specification.

5.3 Do not exceed a dissolved iron content of 6% in sulfuric acid baths, or 10% in hydrochloric (muriatic) acid baths.

5.4 Use only clean water or steam condensate for solutions and rinses. Supply rinse tanks continuously with new water. Do not permit the total amount of acid or dissolved salts due to carry-over to exceed two grams per liter (0.2% by weight).

5.5 To minimize carry-over, suspend all steel briefly over the acid tank from which it has been withdrawn and permit the major portion of the acid to drain.

5.6 Remove deleterious smut, unreacted acid or alkali, metal deposits, or other contaminants.

5.7 Do not stack pickled steel surfaces in contact with one another until completely dry.

5.8 Apply paint before visible rusting occurs.

6. Inspection

6.1 All work and materials supplied under this specification shall be subject to timely inspection by the purchaser or his authorized representative. The contractor shall correct such work or replace such material as is found defective under this specification. In case of dispute the arbitration or settlement procedure established in the procurement documents, if any, shall be followed. If no arbitration or settlement procedure is established, the procedure specified by the American Arbitration Association shall be used.

6.2 The procurement documents covering work or purchase should establish the responsibility for testing and for any required affidavit certifying full compliance with the specification.

7. Safety

7.1 All safety requirements stated in this specification and its component parts apply in addition to any applicable federal, state, and local rules and requirements. They also shall be in accord with instructions and requirements of insurance underwriters.

8. Notes

8.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility or incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

8.2 A Commentary Section is available (Chapter 2 of Volume 2 of the Steel Structures Painting Manual) and contains additional information and data relevant to this specification. The Surface Preparation Commentary, SSPC-SP COM, is not part of this specification. The table below lists the subjects discussed relevant to pickling and appropriate Commentary Section.

Subject	SSPC-SP COM Section
Degree of Cleaning	11
Film Thickness	10
Inhibitors	9
Rust Back	8
Weld Spatter	4.1
Visual Standards	7

Steel Structures Painting Council
SURFACE PREPARATION SPECIFICATION NO. 10
Near-White Blast Cleaning

1. Scope

1.1 This specification covers the requirements for Near-White Blast Cleaning of steel surfaces by the use of abrasives.

2. Definition

2.1 A Near-White Blast Cleaned surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, mill scale, rust, paint, oxides, corrosion products, and other foreign matter, except for staining as noted in Section 2.2.

2.2 Staining shall be limited to no more than 5 percent of each square inch of surface area and may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied paint.

2.3 ACCEPTABLE VARIATIONS IN APPEARANCE THAT DO NOT AFFECT SURFACE CLEANLINESS as defined in Sections 2.1 and 2.2 include variations caused by type of steel, original surface condition, thickness of the steel, weld metal, mill or fabrication marks, heat treating, heat affected zones, blasting abrasives, and differences in the blast pattern.

2.4 When painting is specified, the surface shall be roughened to a degree suitable for the specified paint system.

2.5 Immediately prior to paint application, the surface shall comply with the degree of cleaning as specified herein.

2.6 SSPC-Vis 1 or other visual standards of surface preparation may be specified to supplement the written definition.
*NOTE: Additional information on visual standards is available in Section A.4 of the Appendix.

3. Blast Cleaning Abrasives

3.1 The selection of abrasive size and type shall be based on the type, grade, and surface condition of the steel to be cleaned, type of blast cleaning system employed, the finished surface to be produced (cleanliness and roughness), and whether the abrasive will be recycled.

3.2 The cleanliness and size of recycled abrasives shall be maintained to insure compliance with this specification.

3.3 The blast cleaning abrasive shall be dry and free of oil, grease, and other harmful materials at the time of use.

3.4 Any limitations or restrictions on the use of specific abrasives, quantity of contaminants, or degree of embedment shall be included in the procurement documents (project specification) covering the work, since abrasive embedment and abrasives containing contaminants may not be acceptable for some service requirements.
*NOTE: Additional information on abrasive selection is available in Section A.2 of the Appendix.

4. Reference Standards

4.1 If there is a conflict between the cited reference standards and this specification, this specification shall prevail unless otherwise indicated in the procurement documents (project specification).

4.2 The standards referenced in this specification are:

SSPC-SP 1	Solvent Cleaning
SSPC-Vis 1	Pictorial Surface Preparation Standards for Painting Steel Surfaces

5. Procedure Before Blast Cleaning

5.1 Before blast cleaning, visible deposits of oil or grease shall be removed by any of the methods specified in SSPC-SP 1 or other agreed upon methods.

5.2 Before blast cleaning, surface imperfections such as sharp fins, sharp edges, weld spatter, or burning slag should be removed from the surface to the extent required by the procurement documents (project specification).
*NOTE: Additional information on surface imperfections is available in Section A.5 of the Appendix.

6. Blast Cleaning Methods and Operation

6.1 Clean, dry, compressed air shall be used for nozzle blasting. Moisture separators, oil separators, traps

*Notes are not requirements of this specification.

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or other equipment may be necessary to achieve this requirement.

6.2 Any of the following methods of surface preparation may be used to achieve a Near-White Blast Cleaned surface:

6.2.1 Dry abrasive blasting using compressed air, blast nozzles, and abrasive.

6.2.2 Dry abrasive blasting using a closed cycle, recirculating abrasive system with compressed air, blast nozzle, and abrasive, with or without vacuum for dust and abrasive recovery.

6.2.3 Dry abrasive blasting, using a closed cycle, recirculating abrasive system with centrifugal wheels and abrasive.

6.3 Other methods of surface preparation (such as wet abrasive blasting) may be used to achieve a Near-White Blast Cleaned surface by mutual agreement between the party responsible for performing the work and the party responsible for establishing the requirements or his representative.
*NOTE: If wet abrasive blasting is used, information on the use of inhibitors to prevent the formation of rust immediately after wet blast cleaning is contained in Section A.9 of the Appendix

7. Procedures Following Blast Cleaning and Immediately Prior to Painting

7.1 Visible deposits of oil, grease, or other contaminants shall be removed by any of the methods specified in SSPC-SP 1 or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

7.2 Dust and loose residues shall be removed from prepared surfaces by brushing, blowing off with clean, dry air, vacuum cleaning or other methods agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work. Moisture separators, oil separators, traps, or other equipment may be necessary to achieve clean, dry air.

7.3 After blast cleaning, surface imperfections which remain (i.e., sharp fins, sharp edges, weld spatter, burning slag, scabs, slivers, etc.) shall be removed to the extent required in the procurement documents (project specification). Any damage to the surface profile resulting from the removal of surface imperfections shall be corrected to meet the requirements of Section 2.4.
*NOTE: Additional information on surface imperfections is contained in Section A.5 of the Appendix.

7.4 Any visible rust that forms on the surface of the steel after blast cleaning shall be removed by reblasting the rusted areas to meet the requirements of this specification before painting.
*NOTE: Information on rust-back (rerusting) and surface condensation is contained in Sections A.7 and A.8 of the Appendix.

8. Inspection

8.1 Work and materials supplied under this specification are subject to inspection by the party responsible for establishing the requirements or his representative. Materials and work areas shall be accessible to the inspector. The procedures and times of inspection shall be as agreed upon by the party responsible for establishing the requirements and the party responsible for performing the work.

8.2 Conditions not complying with this specification shall be corrected. In case of dispute the arbitration or settlement procedure established in the procurement documents (project specification) shall be followed. If no arbitration or settlement procedure is established, then the procedure established by the American Arbitration Association shall be used.

8.3 The procurement documents (project specification) should establish the responsibility for inspection and for any required affidavit certifying compliance with the specification.

9. Safety and Environmental Requirements

9.1 Blast cleaning is a hazardous operation. Therefore, all work shall be conducted in such a manner to comply with all applicable insurance underwriter, local, state, and federal safety and environmental rules and requirements.
*NOTE: SSPC-PA Guide 3, "A Guide to Safety in Paint Application," addresses safety concerns for coating work.

10. Comments

10.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the Steel Structures Painting Council cannot assume responsibility nor incur any obligation resulting from the use of any materials, paints, or methods specified therein, or of the specification itself.

10.2 Additional information and data relative to this specification are contained in the following brief Appendix. More detailed information and data are presented in a separate document, SSPC-SP COM, "Surface Preparation Commentary." The recommendations contained in the Notes, Appendix, and SSPC-SP COM are believed to represent good practice, but are not to be considered as requirements of the specification. The table below lists the subjects discussed relevant to Near-White Blast Cleaning

and appropriate section of SSPC-SP COM.

Subject	Commentary Section
Abrasive Selection	5.
Degree of Cleaning	11.10
Film Thickness	10.
Wet Abrasive Blast Cleaning	9.
Maintenance Painting	3.2
Rust Back (Rerusting)	8.
Surface Profile	6.
Visual Standards	7.
Weld Spatter	4.1

A. Appendix

A.1 FUNCTION — Near-White Blast Cleaning (SSPC-SP 10) provides a greater degree of cleaning than Commercial Blast Cleaning (SSPC-SP 6) but less than White Metal Blast Cleaning (SSPC-SP 5). It should be used where a high degree of blast cleaning is required. The primary functions of blast cleaning before painting are: (a) to remove material from the surface that can cause early failure of the coating system, and (b) to obtain a suitable surface roughness.

A.2 ABRASIVE SELECTION — Types of metallic and non-metallic abrasives are discussed in the Surface Preparation Commentary (SSPC-SP COM). It is important to recognize that blasting abrasives may become embedded in or leave residues on the surface of the steel during preparation. While normally such embedment or residues are not detrimental, care should be taken (particularly if the prepared steel is to be used in an immersion environment) to assure that the abrasive is free from detrimental amounts of water soluble, solvent soluble, acid soluble, or other such soluble materials.

A.3 SURFACE PROFILE — Surface profile is the roughness of the surface which results from abrasive blast cleaning. The profile depth (or height) is dependent upon the size, type, and hardness of the abrasive, particle velocity and angle of impact, hardness of the surface, amount of recycling, and the proper maintenance of working mixtures of grit and/or shot.

The allowable minimum/maximum height of profile is usually dependent upon the thickness of the paint to be applied. Large particle sized abrasives (particularly metallic) can produce a profile which may be too deep to be adequately covered by a single thin film coat. Accordingly, it is recommended that the use of larger abrasives be avoided in these cases. However, larger abrasives may be needed for thick film coatings or to facilitate removal of heavy mill scale or rust. If control of profile (minimum/maximum) is deemed to be significant to coatings performance, it should be addressed in the procurement documents (project specification).

Typical maximum profile heights achieved with commercial abrasive media are shown in Table 8 of the Surface Preparation Commentary (SSPC-SP COM). Methods (i.e., comparators, replica tape, depth micrometers) are available to aid in estimating the profile of surfaces blast cleaned with sand, steel grit, and steel shot.

A.4 VISUAL STANDARDS — Note that the use of visual standards in conjunction with this specification is required only when they are specified in the procurement documents (project specification) covering the work. It is recommended, however, that the use of visual standards be made mandatory in the procurement documents (project specification).

SSPC-Vis 1, "Pictorial Surface Preparation Standards for Painting Steel Surfaces," provides color photographs for the various grades of surface preparation as a function of the initial condition of the steel. The following table lists the pictorial standards for this specification that are applicable to the rust grades listed below.

Rust Grade	Adherent Mill Scale	Rusting Mill Scale	Rusted	Pitted and Rusted
Pictorial Standards	A Sa 2-½	B Sa 2-½	C Sa 2-½	D Sa 2-½

Many other visual standards are available and are described in Section 7 of the Commentary (SSPC-SP COM).

A.5 SURFACE IMPERFECTIONS — Surface imperfections can cause premature failure when the service is severe. Coatings tend to pull away from sharp edges and projections, leaving little or no coating to protect the underlying steel. Other features which are difficult to properly cover and protect include crevices, weld porosity, laminations, etc. The high cost of the methods to remedy the surface imperfections requires weighing the benefits of edge rounding, weld spatter removal, etc., versus a potential coating failure.

Poorly adhering contaminants, such as weld slag residues, loose weld spatter, and some minor surface laminations, may be removed during the blast cleaning operation. Other surface defects (steel laminations, weld porosities, or deep corrosion pits) may not be evident until the surface preparation has been completed. Therefore, proper planning for such surface repair work is essential since the timing of the repairs may occur before, during, or after the blast cleaning operation. Section 4 of the Commentary (SSPC-SP COM) contains additional information on surface imperfections.

A.6 CHEMICAL CONTAMINATION — Steel contaminated with soluble salts (i.e., chlorides and sulfates) develops rust-back rapidly at intermediate and high humidities. These soluble salts can be present on the steel surface prior to blast cleaning as a result of atmospheric contamination. In addition, contaminants can be de-

posited on the steel surface during blast cleaning whenever the abrasive is contaminated. Therefore, rust-back can be minimized by removing these salts from the steel surface, preferably before blast cleaning and eliminating sources of recontamination during and after blast cleaning. Identification of the contaminants along with their concentrations may be obtained from laboratory and field tests. A number of tests for soluble salts are now under study by the SSPC, ASTM, Maritime Administration, and ISO.

A.7 RUST-BACK — Rust-back (rerusting) occurs when freshly cleaned steel is exposed to conditions of high humidity, moisture, contamination, or a corrosive atmosphere. The time interval between blast cleaning and rust-back will vary greatly from one environment to another. Under mild ambient conditions it is best to blast clean and coat a surface the same day. Severe conditions may require coating more quickly while for exposure under controlled conditions the coating time may be extended. Under no circumstances should the steel be permitted to rust-back before painting regardless of the time elapsed (see Appendix A.6).

A.8 DEW POINT — Moisture condenses on any surface that is colder than the dew point of the surrounding air. It is, therefore, recommended that the temperature of steel surface be at least 5 degrees F (3 degrees C) above the dew point during dry blast cleaning operations. It is advisable to visually inspect for moisture and periodically check the surface temperature and dew point during blast cleaning operations. It is important that the application of paint over a damp surface be avoided.

A.9 WET ABRASIVE BLAST CLEANING — Steel that is wet abrasive blast cleaned may rust rapidly. Clean water should be used for rinsing (studies have shown that water of at least 15,000 ohm-cm resistivity is preferred). It may be necessary that inhibitors be added to the water or applied to the surface immediately after blast cleaning to temporarily prevent rust formation. The coating should then be applied before any rusting is visible. One inhibitive treatment for blast cleaned surfaces is water containing 0.32% sodium nitrite and 1.28% by weight secondary ammonium phosphate (dibasic).
CAUTION: Some inhibitive treatments may interfere with the performance of certain coating systems.

A.10 FILM THICKNESS — It is essential that ample coating be applied after blast cleaning to adequately cover the peaks of the surface profile. The dry paint film thickness above the peaks of the profile should equal the thickness known to be needed for the desired protection. If the dry film thickness over the peaks is inadequate, premature rust-through or failure will occur. To assure that coating thicknesses are properly measured, refer to SSPC-PA 2, "Measurement of Dry Paint Thickness with Magnetic Gages."

A.11 MAINTENANCE AND REPAIR PAINTING — When this specification is used in maintenance painting, specific instructions should be given on the extent of surface to be blast cleaned or spot blast cleaned to this degree of cleanliness. SSPC-PA Guide 4, "Guide to Maintenance Repainting with Oil Base or Alkyd Painting Systems," provides a description of accepted practices for retaining old sound paint, removing unsound paint, feathering, and spot cleaning.

Steel Structures Painting Council
PAINT APPLICATION SPECIFICATION NO. 2
Measurement of Dry Paint Thickness with Magnetic Gages

1. Scope

1.1 GENERAL: This method describes the procedures to measure the thickness of a dry film of a nonmagnetic coating applied on a magnetic substrate using commercially available magnetic gages. These procedures are intended to supplement manufacturers' instructions for the manual operation of the gages. The types of gages covered are nondestructive to the film being measured.

1.2 GAGE TYPES: Magnetic gages of two types may be used:

Type 1 — Pull-off Gages (such as Mikrotest, Inspector, and Tinsley Thickness Gages, and the Elcometer Pull-Off Gage); and

Type 2 — Fixed Probe Gages (such as Elcometer Thickness Gage, Minitector, General Electric Type B Thickness Gage, Verimeter, Permascope, and Dermitron).

2. Calibration and Measurement Procedures

2.1 GENERAL:

2.1.1 ACCESS TO BARE SUBSTRATE: To determine the effect of the substrate condition on the gage readings, access is required to some unpainted areas. Small representative areas may be masked-off during the painting. If the paint has already been applied to the entire surface, small areas of paint may be removed and later patched. An alternative procedure that may be specified is to provide separate unpainted reference panels of similar steel and surface condition. These would be used as the bare substrate in the procedures of Section 2.2 and 2.3.

2.1.2 Repeated gage readings, even at points close together, may differ considerably due to small surface irregularities. Therefore, three (3) gage readings shall be made for each spot measurement of either the substrate or the paint. Move the probe a distance of one to three inches for each new gage reading. Discard any unusually high or low gage reading that cannot be repeated consistently. Take the average (mean) of the three gage readings as the spot measurement.

2.2 CALIBRATION MEASUREMENTS — TYPE I PULL-OFF GAGES:

2.2.1 For Type 1 gages, the preferred calibration standards are small, chromeplated steel panels that are available from the National Bureau of Standards in coating thicknesses from 0.5 to 80 mils (12.5 to 2030 microns) or more. The plated panels are flat smooth steel 1.125 x 1.125 inches (2.85 x 2.85 cm) in size. They exceed the critical mass of steel needed to satisfy the magnetic field of the Type 1 (pull-off) magnets. Shims of plastic or of non-magnetic metals which are acceptable for calibration of Type 2 (fixed probe) gages should *not* be used for calibration of the Type 1 gages.

2.2.2 Using the Type 1 (pull-off) gage, measure the thickness of a series of calibration standards covering the expected range of paint thickness. Record the calibration correction either + or − required at each standard thickness. To guard against gage drift during use, recheck the gage at least once during each work shift with one or more of the standards. In case of dispute the buyer and seller should agree on the details and frequency of calibrations.

2.2.3 When the gage adjustment has drifted so far that large corrections are needed, it is advisable to readjust closer to the standard values and recalibrate. When the gage can no longer be adjusted into reasonable agreement with the reference standards, have it rebuilt or replaced.

2.2.4 Measure (A), the bare substrate, at a number of spots to obtain a representative average value. Note the gage is *not* to be calibrated on the bare substrate.

2.2.5 Measure (B), the dry paint film, at the number of spots specified in Section 3.

2.2.6 Subtract the readings (A) and (B) to obtain the thickness of the paint film.

NOTE: When an uncalibrated gage is used, it is necessary to correct the A and B readings using the corrections as determined from Section 2.2.2.

2.3 CALIBRATION AND MEASUREMENT — TYPE 2, FIXED PROBED GAGES

2.3.1 For Type 2 (fixed probe) gages, shims of plastic or of non-magnetic metals laid on the appropriately cleaned steel base, at least 3 x 3 x 0.125 inches (7.6 x 7.6 x 0.32 cm), are suitable working standads. During calibration hold the gage firmly enough to press the shim tightly against the steel surface. Avoid excessive pressure that might indent the plastic or, on a blast cleaned surface, might impress the steel peaks into the under surface of the plastic. A very smooth plate of mild steel free of mill scale and rust is suitable for the zero thickness standard.

Because of the stronger magnetic field of the Type 2 (fixed probe) gages, the small, National Bureau of Standards calibration standards, acceptable for Type 1 (pull-off) gages, shall *not* be used with Type 2 gages.

2.3.2 It is IMPORTANT to confirm the gage setting by measuring the shim at several other areas of the bare substrate. Readjust the gage as needed to obtain an average setting representative of the substrate.

2.3.3 Spot measurement of paint: With the gage adjusted as above, measure the dry paint film as specified in Section 3. The gage readings indicate the paint film thickness.

2.3.4 Recheck the gage setting at frequent intervals during a long series of measurements.

3. Number of Measurements for Conformance to a Thickness Specification

3.1 NUMBER OF MEASUREMENTS AND MINIMUM THICKNESS: Make five (5) separate spot measurements (average of three readings, see Section 2.2) spaced evenly over each 100 square feet (9.3 square meters) of area to be measured. The *average* of five spot measurements for each such 100 square foot area shall not be less than the specified thickness. No single spot measurement in any 100 square foot area shall be less than 80% of the specified thickness. Any one of three readings which are averaged to produce each spot measurement may under-run by a greater amount. The five spot measurements shall be made for each 100 square feet of area as follows:

3.1.1 For structures not exceeding 300 square feet in area, each 100 square foot area shall be measured.

3.1.2 For structures not exceeding 1,000 square feet in area, three 100 square foot areas shall be randomly selected and measured.

3.1.3 For structures exceeding 1,000 square feet in area, the first 1,000 square feet shall be measured as stated in Section 3.1.2 and for each additional 1,000 square feet of area or increment thereof, one 100 square foot area shall be randomly selected and measured.

3.1.4 If the dry film thickness for any 100 square foot area (Sections 3.1.2 and 3.1.3) is not in compliance with the requirements of Section 3.1, then each 100 square foot area shall be measured.

3.2 Other size areas or number of spot measurements may be specified in the procurement documents as appropriate for the size and shape of the structure to be measured.

3.3 THICKNESS LIMITS: Some paints are especially sensitive to high or low film thickness. In all cases, limitations on maximum or minimum film thickness specified in the manufacturer's instructions shall be followed.

4. Accuracy

4.1 GAGE ACCURACY: All of the above magnetic gages, if properly adjusted and in good condition, are inherently accurate to within ± 15% (most gages within ± 10%). It should be noted that this is only the accuracy built into the gages themselves.

4.2 ITEMS WHICH AFFECT GAGE ACCURACY: Much larger, external errors may be caused by variations in method of use of gages or by unevenness of the surface of the substrate or of the coatings. Also, any other films present on the steel (rust or mill scale or even a blast cleaned profile zone) will add to the apparent thickness of the applied paint film. Thus, for accurate use of the magnetic gages, some knowledge is required of the nature of the surface being painted and of its effect on the gage readings. For this purpose the gage operator must have access to at least small areas of the unpainted substrate as in Section 2.1.1. As a minimum, he must know whether he is measuring only paint, or paint plus mill scale, or paint plus steel surface roughness.

5. Notes

5.1 While every precaution is taken to insure that all information furnished in SSPC specifications is as accurate, complete, and useful as possible, the SSPC cannot assume responsibility nor incur any obligation resulting from the use of any material, paint, or method specified therein.

5.2 PRINCIPLES OF THE MAGNETIC GAGE: Each of these gages can sense and indicate only the distance between the magnetic surface of the steel and the small rounded tip of the magnet that rests on the top surface of the paint. This measured distance, from the top surface of the paint, must be corrected for the thickness of any extraneous films or other interfering conditions on the surface of the steel. Such correction is made, as described in Sections 2.2 and 2.3. It might be noted that many disagreements in thickness reports arise from different conceptions of this correction, or of just what is measured by the gages under various conditions and methods of use.

5.2.1 Type 1 (pull-off) gages use a type of spring balance to pull a small permanent magnet from the surface of the painted steel. The magnetic force holding to the surface varies inversely as a non-linear function of the distance between magnet and steel, i.e., the thickness of the dry paint film (plus any other films present).

Normally, Type 1 gages are not adjusted or reset for each new series of measurements. In fact, adjustment is not advisable unless the gage is to be very carefully calibrated with National Bureau of Standards calibration standards as indicated in Section 2.2.1. In normal use the gage may not require adjustment for months.

Shims of sheet plastic or of non-magnetic metals which are permissible for calibrating Type 2, fixed probe gages, should not be used for calibration of Type 1 gages. Such shims are usually fairly rigid and curved, and do not

lie perfectly flat even on a smooth steel test surface. Near the pull-off point of the calibration measurements with any Type 1 gage, the shim frequently springs back from the steel surface, raising the magnet too soon and causing erroneous calibration readings.

5.2.2 Type 2 (fixed probe) gages depend on changes in magnetic flux within the probe or the instrument. The magnitudes of these changes also are an inverse (non-linear) function of the distance between the probe and the steel surface under the paint. The probes of these gages remain in contact with the paint during the measurement. Type 2 gages differ also in that they are usually adjusted to a selected film thickness value before each new series of measurements.

Type 2 gages should be checked periodically for sensitivity. Using a smooth steel base at least 0.125 inches thick (0.32 cm) and free of mill scale, set the gage with a shim in the thickness range most used. Measure several other shims, thicker and thinner than the setting. The gage should respond fully to the difference in thickness of the shims.

5.3 REPEATABILITY: These magnetic gages are necessarily sensitive to very small irregularities of the paint surface or of the steel surface directly below the small rounded tip of the magnet. The gage readings are also influenced by the steadiness of the operator's hand. Thus, repeated gage readings on a rough surface, even at points very close together, frequently differ considerably. However, repeated gage readings within 0.2 mils (5 microns) have been reported for average readings taken in a limited area and on a variety of surfaces.

5.4 ZERO SETTING: It is sometimes suggested that the magnetic gages be adjusted or set at the scale zero (0), with the gage applied to a very smooth uncoated steel panel. However, the zero point on most of the gage scales appears to be least accurately positioned. Therefore, the scale should be set to indicate most accurately in the range of thicknesses that are to be measured. It would be still worse to "zero" the gage on a rough bare steel surface. This would misplace the nonlinear scale considerably.

5.5 ROUGHNESS OF THE STEEL SURFACE: If the steel surface is smooth and even, its surface plane is the effective magnetic surface, and the distance indicated by the gage is truly the paint thickness. However, if the steel is roughened, as by blast cleaning, the "apparent" or effective magnetic surface that the gage senses is an imaginary plane located between the peaks and valleys of the surface profile. For this reason, paint thickness would appear to the gage to be greater than it actually is above the peaks. The procedures of Section 2.2 and 2.3 provide a correction for this magnetic effect of the surface profile. Actually, the distance from the plane of the peaks to the effective magnetic plane is much less than the peak-to-valley distance. A typical sand blast profile, 2.8 mils (71 microns) maximum height, increased Mikrotest readings on a 4 mil (102 microns) paint coat by only 0.5 mils (13 microns).

5.6 DIRTY, TACKY, OR SOFT FILMS: The surface of the paint and the probe of the gage must be free from dust, grease, and other foreign matter in order to obtain close contact of the probe with the paint and also to avoid adhesion of the magnet. The accuracy of the measurement will be affected if the coating is tacky or excessively soft. Tacky paint films also cause unwanted adhesion of the magnet. Unusually soft films may be dented by the pressure of the probe. Soft or tacky films can sometimes be measured satisfactorily by putting a shim on the film, measuring total thickness of paint plus shim, and subtracting shim thickness.

5.7 ALLOY STEEL SUBSTRATES: Appreciable differences in certain magnetic properties of the substrates will affect the magnetic gage readings. However, such differences among most mild low-carbon steels are insignificant. Also, at least two of the high-strength, low-alloy steels have no appreciably different effect on the gages. For higher alloy steels, the gage response should be checked. In any event, the gage should be recalibrated on the same steel over which the coating has been applied.

5.8 PROXIMITY TO EDGES: The magnetic gages are sensitive to geometrical discontinuities of the steel, as at holes, corners, or edges. The sensitivity to edge effects and discontinuities varies from gage to gage. Measurements closer than one inch (2.5 cm) from the discontinuity may not be valid unless the gage is calibrated specifically for that location. It may be used as a "go, no-go" gage at such locations by setting or calibrating it for one thickness under precisely similar conditions.

5.9 PROXIMITY TO OTHER MASS OF STEEL: Some of the Type 2 gages in particular are sensitive to the presence of another mass of steel close to the body of the gage. This effect may extend as much as three inches (7.6 cm) from an inside angle.

5.10 CURVATURE OF STEEL SURFACE: Magnetic gage readings may be affected by the surface curvature in proportion to the degree of departure from flatness. If the curvature is appreciable, valid measurements may still be obtained by calibrating or setting the gage on a similarly curved surface.

5.11 TILT OF PROBE: All of the magnets or probes must be held perpendicular to the painted surface to produce valid measurements.

5.12 OTHER MAGNETIC FIELDS: Strong magnetic fields, as from welding equipment or nearby power lines, will interfere with operation of the gages. Also, residual magnetism in the steel substrate may affect gage readings. With two-pole gages in such cases, it is recommended that the readings before and after reversing the pole positions be averaged. Other gages may require demagnetization of the steel.

5.13 EXTREMES OF TEMPERATURE: Most of the magnetic gages have operated satisfactorily at 40° F and 120° F (4° C and 49° C). However, if such temperature extremes are met in the field, the gage might well be checked with at least one reference standard after both the standard and the gage are brought to the same ambient temperature.

5.14 VIBRATION: The accuracy of the Type 1 (pull-off) gages is affected by traffic, machinery, concussions, etc. When these gages are set up for calibration or measurement of paint films, there should be no apparent vibration.